MACHINE DESIGN

March 1943

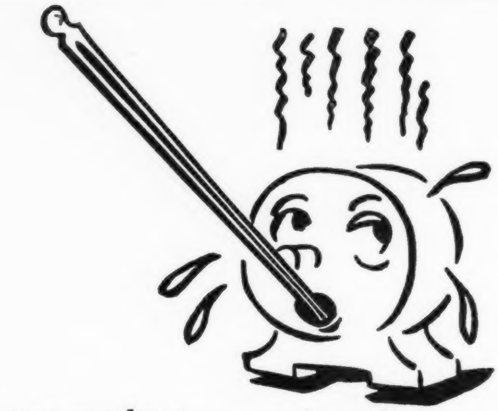
In This Issue:

Plastics at Temperature Extremes

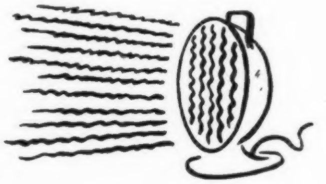
Strain-Rosette Analysis

Motors Run a Fever?

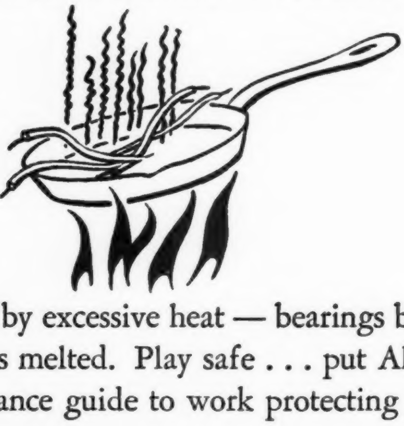
No wonder if they do more often today. They're working 3 and 4 times as many hours a year as in peace!



When a motor runs hot in your plant, do your men have explicit directions for locating the cause? If not, send in for your free copy of "Guide to Wartime Care of Electric Motors". Its QUICK DIAGNOSIS OF MOTOR AILMENTS is invaluable!



Friction makes heat — and so does electrical resistance. Pages 8 and 9 of Allis-Chalmers' new book tell how wartime preventive maintenance should fight friction . . . pages 16 and 17 outline strategy for preventing overload. Recommendations are simple, practical, *geared to wartime* — ideal for training.

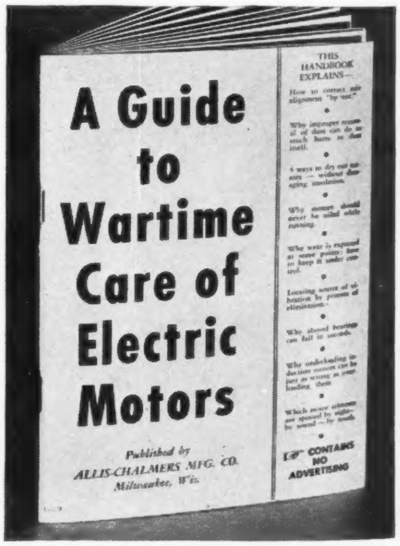


Insulation is "fried" by excessive heat — bearings burned out — soldered connections melted. Play safe . . . put Allis-Chalmers' new motor maintenance guide to work protecting *your* motors!

HERE'S the arithmetic of the wartime motor maintenance problem: motors that worked 1800 hours in a peace year now work up to *8700 hours!*

A killing schedule—yet motors now must last *longer* than ever before — and wishing won't make it so.

One thing will: the new *wartime* standard of motor care set forth in Allis-Chalmers' new motor maintenance guide. Already, 70,000 copies are in use in plants all over the U. S.!



Contents of this valuable new publication include the 9 main enemies of electric motors and how to fight them . . . dust, stray oil, moisture, friction, misalignment, vibration, uneven wear, overload and underload. Send in today for *your* free copy to ALLIS-CHALMERS, MILWAUKEE, WIS. A 1591

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WE WORK FOR VICTORY — WE PLAN FOR PEACE

MACHINE DESIGN

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Contents

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Itemized Index

Classified for Convenience when Studying Specific Design Problems

MACHINE DESIGN is indexed in Industrial Arts Index and Engineering Index Service, both available in libraries generally.

Topics

TO MAINTAIN proper pressure automatically in airplane cabins a supercharger-type fan is being developed to sense requirements. As the plane rises the lower density of air allows the fan to run faster with a consequent increase in operating current. A special control scheme interprets this as a need for greater speed and increases the voltage of the supply generator accordingly.

♦

PURCHASERS of electric motors must show that the horsepower applied is no greater than that required for the job, according to a provision in General Conservation Order L-221 announced by WPB.

♦

INSTEAD of preventing water from entering a motor along its shaft, Westinghouse engineers have employed a cap and flinger arrangement to throw any water that may enter into a chamber which drains to the outside.

♦

NEW RUBBER molding technique has been developed in England that saves as much as seventy-five per cent through utilization of felt cores. Also moldings are considerably lighter when formed by this new process which has been developed jointly by the Empire Rubber Co. and Bury Felt Mfg. Co.

♦

APPLICATION of radio frequency heating to speed industrial processes and at the same time increase their efficiency is rapidly coming to the fore. Known as thermal radio, it can be used for laminating an airplane propeller in a few minutes, cementing rubber, hardening metals, curing wood, "stitching" cloth, gluing plywood and performing countless other remarkable operations.

♦

WATER-SENSITIVE switch mounted on underside of aircraft automatically causes the release of rubber boat and its inflation so that when the crew crawls from a crashed plane the raft is waiting for use. Developed by Walter Kidde & Co., carbon dioxide cylinders operate the hatch and inflate the boat.

♦

CANOPY OF WATER spray is being effectively employed on low buildings covering large areas to prevent the interior from heating up on warm days and interfering with the efficiency of the personnel. Installations where the spray has been employed to dissipate solar heat before it strikes the roof have proved so successful that similar protection for other plants is being planned. For a properly designed installation, one-half gallon per minute per hundred square feet of area at seven pounds pressure is effective. Water may be reused because cooling depends on evaporation rather than on water temperature.

♦

OUR WAR production program is now entering a phase in which technological improvements must play a major role. According to Donald M. Nelson, "our production of war goods must be expanded greatly during 1943. . . . For a large part of the increase in production, we must rely on our ability to find ways to make more with what we have."

♦

MECHANICAL brains to sight guns automatically, accurately and instantly are being developed for antiaircraft gunners. Part of the new control utilizes an antenna mounted a short distance from the control room. The antenna may remain fixed, rotate continuously or oscillate through a selected arc. Instruments provide the operator with an indication of the actual angular position at all times and are designed to work perfectly in high winds and low temperatures.

♦

PNEUMATIC chip collector on lathes makes salvage automatic. A jet of air blows the chips into a covered barrel at one end of the machine, preventing contamination which otherwise would happen when chips are shovelled from the floor.

♦

PLIOFILM bags provide hermetically sealed enclosures for shipment of aircraft engines. Bags are heat-sealed mechanically to provide moisture-proof container until engine is installed in a plane.

♦

POSSIBILITY of error in precision lathe work has been minimized as the result of a pilot-light indicating method developed at General Electric Schenectady works. Contact between tool and work closes circuit to indicate zero on micrometer dial, thus removing the personal element in determining exactly when contact is made.

MACHINE DESIGN

Plastics Face Arctic Cold, Tropic Heat!

By John Delmonte
Technical Director
Plastics Industries Technical Institute

Fig. 1—Top—Temperature extremes encountered by our fighters on far-flung battle fronts seriously affect performance of plastic parts in service

IN FILLING numerous applications from the subzero temperatures of high altitudes to the uncomfortable heat of the tropics, organic plastics are called upon to perform difficult service. It has become increasingly important to engineers and designers to familiarize themselves with the physical properties of plastics not only at normal temperatures, but also at temperatures from —60 up to 180 degrees Fahr. Much technical information has been published for properties obtained under ideal laboratory conditions at 70 to 80 degrees Fahr. but too little has appeared on the behavior of plastics at temperature extremes. This article, in addition to reporting various physical properties, will include an analysis of the general effects of temperature on the performance of plastics.

Because engineers and designers have become accustomed to the reasonable constancy

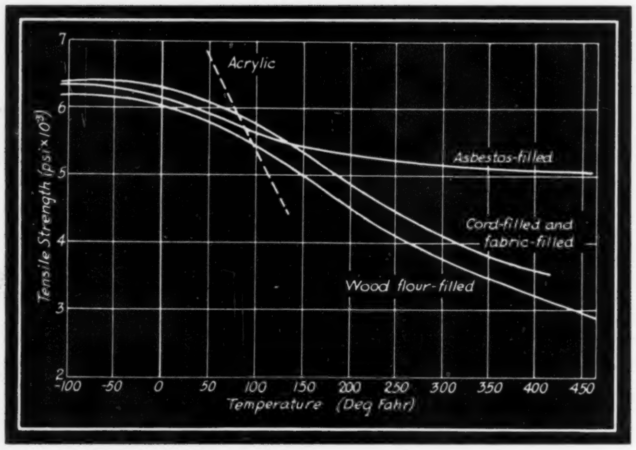
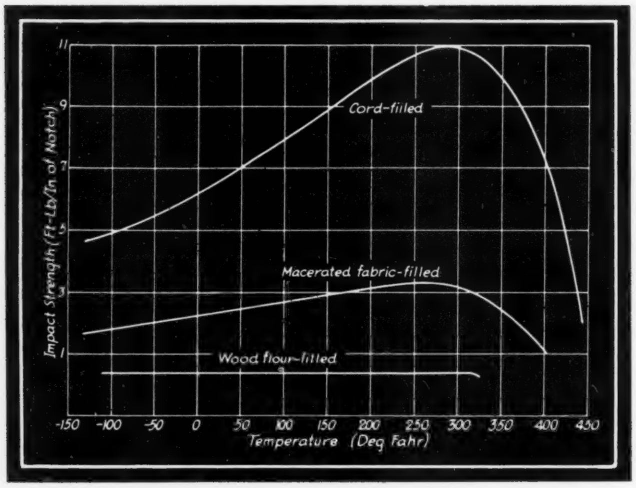


Fig. 2—Above—How temperature affects the strength of phenolic molding compounds (solid lines) and a thermoplastic (broken line)

Fig. 3—Below—Relative impact strength of certain phenolic molding compounds is highest at about 270 degrees



of behavior among metals, too much stress cannot be laid on the importance of property variations at temperature extremes—aside from the requirements of Army and Navy specifications. This applies particularly to organic plastics because of the fundamental fact that, due to their temperature sensitivity, the primary asset of plastics is the ease with which they lend themselves to molding and fabricating operations. Consequently some variation must be expected to occur in properties. While as a general rule thermosetting phenolic, urea, and melamine resins are less affected than thermoplastics such as cellulosic derivatives, polyvinyls, polystyrene, acrylics, and others, all materials experience an appreciable performance change with temperature.

Tensile Strength: As may be expected, tensile strength of plastics decreases with an increase in temperature as illustrated in *Fig.* 2. Much of the data in this curve was taken from a recent paper*. Noteworthy is the fact that cord-filled, as well as woodflour-filled phenolics have the same tensile strength, within the limits of experimental error, over a wide range of temperatures. It is only in such properties as impact strength that a large distinction is observed between these materials, as will be shown later. Asbestos-filled phenolics stand up better at higher temperatures, between 320 and 400 degrees Fahr. From these data it may be surmised that mineral-filled phenolics should be specified for higher temperatures where maximum tensile strength is needed. Examples of such an application include steam conduits and components of ovens or heat-treating equipment.

Also to be borne in mind is the increase in elongation at the same time that tensile strength decreases with

Table I

Relative Punch Strength*

Material	Temperature, degrees Fahr. 23	70	165-170	240-250	[illegible]
Polyvinyl chloride-acetate sheet	160	137	72	5	[illegible]
Polymethyl methacrylate (sheet)	210	163	92	21	[illegible]
Cellulose Acetate (sheet)	210	160	92	40	[illegible]
Cellulose acetate-butyrate (sheet)	175	125	74	12	[illegible]
Laminated phenolic canvas base	210	175	170	145	[illegible]
Polystyrene (molded)	135	115	77	4	[illegible]
Urea-formaldehyde	220	240	240	150	[illegible]
Wood flour-filled phenolic	200	175	130	100	[illegible]

*Values are comparable with one another and are reduced down to the same thickness at $\frac{1}{16}$-inch. The above figures represent pounds required to force a .104-inch punch through the above plastic material and are the average of at least three tests in each case.

temperature. This generally brings on an increase in toughness up to a certain point, because this factor is to some extent a product of elongation and tensile strength. It is significant in such applications as automobile safety glass where a transparent plastic bonds two layers of sheet glass together. Tests have shown considerably higher impact strength at temperatures of 120 degrees Fahr. than at 32 degrees Fahr.

While a stress analyst might be prone to write the tensile strength of plastics in terms of an exponential equation involving temperature as a variable, certain other

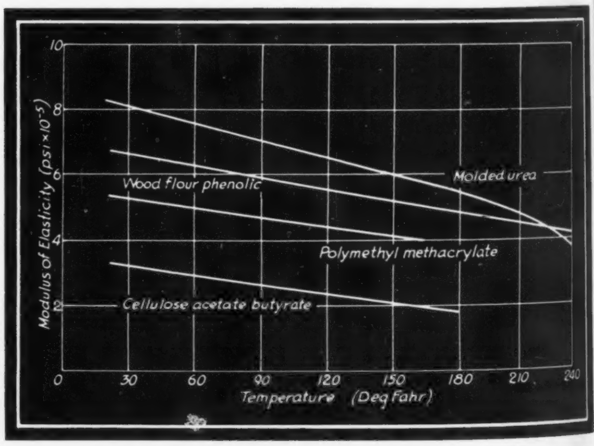


Fig. 4—Curves show variation of elastic modulus with temperature for typical plastics

variables are equally important. For example, methods of manufacture will often decide the physical properties of plastics. A polyvinyl resin in an extruded form may show tensile strengths of 50,000 pounds per square inch whereas in molded forms it may have strengths in the neighborhood of 7000 pounds per square inch. Presence or absence of flow marks and weld marks also makes a difference in tensile strength.

* "Temperature vs Strength for Phenolics"—T. S. Carswell, D. Telfair and R. U. Haslanger, A.S.T.M. Annual Meeting, June, 1942.

Punch Strength: A convenient index of strength comparison worked out by the author is punch strength determination. Values covering a wide range of temperatures are tabulated in Table I. This is a complete comparison of all major classifications of thermosetting and thermoplastic organic plastics. In the test method a small punch and die are mounted upon an arbor press equipped with a spring scale for easy reading. Tests are performed in a matter of a few seconds, and effects of temperature are readily determined because of the ability to place samples and test apparatus within a temperature-controlled chamber without much difficulty.

While most of the thermoplastics appear to hold up satisfactorily at temperatures up to 140 degrees Fahr., values of punch strength fall off rapidly beyond that range, the sharp break in the curves corresponding in some instances to the A.S.TM. values of heat distortion points for the plastic materials. Table I may be conveniently used as a comparative index of changes in physical properties of plastics with variation in temperature.

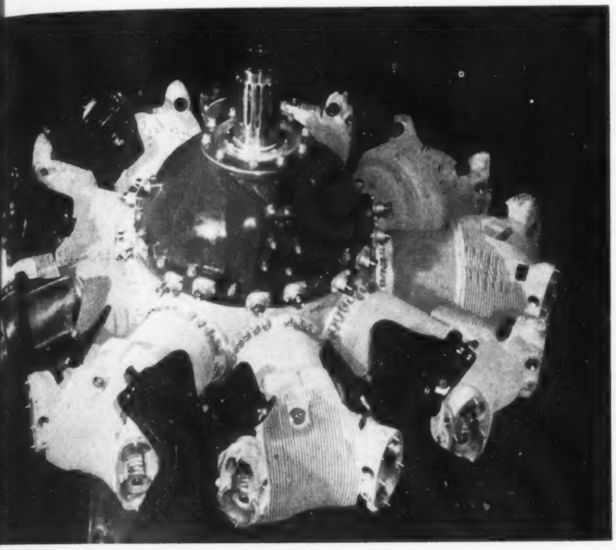


Fig. 5—Subject to extremes of temperature, plastic baffles between cylinders of radial engines successfully meet exacting demands

Above 240-250 degrees Fahr. values of punch strength for thermoplastics are low, almost being indeterminate with any degree of accuracy using present equipment inas much as they flow under a pressure of a few pounds acting upon the punch. No values above 300 degrees Fahr. were obtained for the polyvinyl co-polymer sheet which decomposed. Above 250 degrees Fahr. urea compounds were somewhat unreliable in punch strength readings as they tended to blister severely.

Impact Strength: One of the most sought-after properties among organic plastics in the present war program is high impact strength at both subzero and high temperatures. As shown in *Fig.* 3, the impact strength of some of the plastics increases with temperature up to a certain point. These data also are abstracted from the paper previously mentioned. While thermosetting phenolic plastics have enjoyed wide acceptance by the armed forces over the broadest temperature range, certain thermoplastics have recently been accepted by the ordnance department for temperatures from —40 to 170 degrees Fahr. For example, molded grips and handles for small arms have been approved for special cellulose acetate butyrate formulas. Likewise canvas duck treated with solutions of the same plastic are employed for bayonet scabbard housings by the infantry. Of paramount importance in these applications is the high impact strength over the temperature range indicated.

In aircraft applications engineers have been much concerned with impact qualities at high altitudes where plasticized thermoplastics give indication of embrittlement. A few misapplications appeared at the start of the war when engineers and designers promiscuously specified plastics which had proved satisfactory in applications at room temperature for service at the low temperatures prevailing at high altitude. This was only a temporary condition, however, until correct materials were developed.

Modulus of Elasticity: Contrary to popular belief the modulus of elasticity does not excessively decrease with an increase in temperature. This fact is not always readily observed in the laboratory because in conventional testing methods for evaluating the modulus, the time of applying load is appreciably long and creep phenomena may obscure true elastic phenomena. Data on creep characteristics are given later. In *Fig.* 4 however, the variation

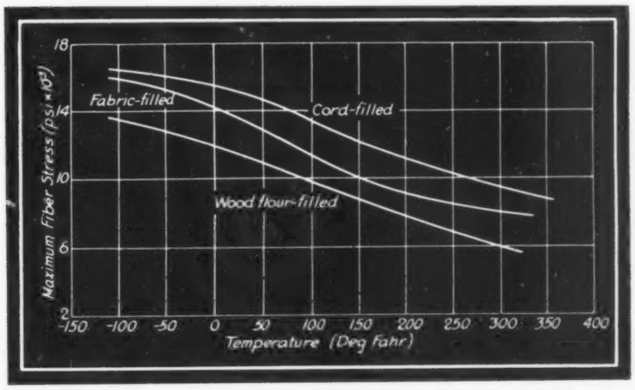
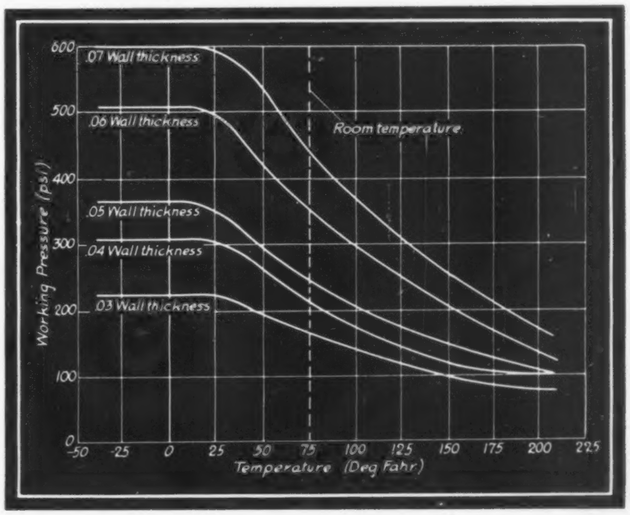


Fig. 6—Above—Maximum fiber stress in bending is shown for phenolic molding compounds at various temperatures

Fig. 7—Below—Safe working pressures for thermoplastic tubing demonstrate the effect of high temperature on strength. Assumed safety factor five



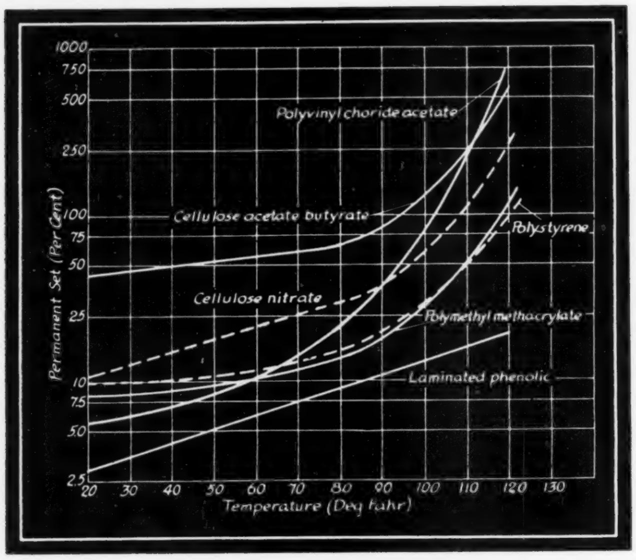
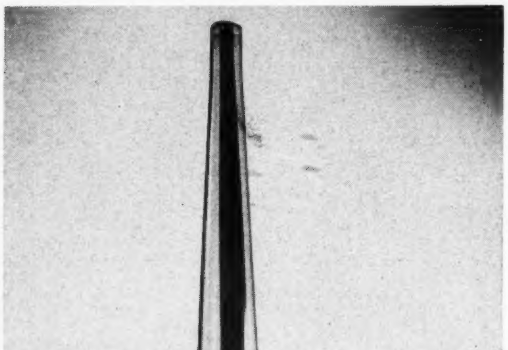


Fig. 8—Creep characteristics obtained by stressing specimens for four days at 1000 pounds per square inch maximum fiber stress followed by four days of recovery

Fig. 9—High strength and proper dielectric properties over a wide range of temperature are prime requirements of this molded plastic aerial mast base for fighter planes



of modulus of elasticity with temperature is given for several plastics. These values of modulus are arrived at from instantaneous measurements of deflection by the simple cantilever beam methods developed at Plastics Institute. The modulus is computed from the formula:

$$E = WL^3/3Iy$$

where I = moment of inertia, inches^4; L = test length, inches; W = weight at end of beam pounds; and y = deflection, inches.

A maximum fiber stress of 1000 pounds per square inch prevailed in all test measurements. Deflection at end of beam was measured with a micrometer depth gage. Readings were made within a space of a few seconds and rechecked several times in order to obtain a true value of modulus of elasticity. Particular difficulty was encountered in measuring the modulus of thermoplastics at higher temperatures, because they crept so rapidly as to enable only approximate values to be obtained. Likewise at still higher temperatures mica-filled phenolics gave the same type of difficulty.

Flexural Strength: Maximum fiber stress as determined by the flexural method varied considerably with temperature as indicated in *Fig.* 6, for several phenolics. Data of this character should prove of fundamental interest to designers concerned with meeting temperature specifications for plastics. Another interesting observation of safe working stress in polyvinylidene chloride tubing appears in *Fig.* 7. Of significance is the rapid decline in working stress at higher temperatures. Conduits of this plastic have demonstrated their chemical resistance and serviceability and have saved much iron and copper.

Temperature Greatly Affects Creep

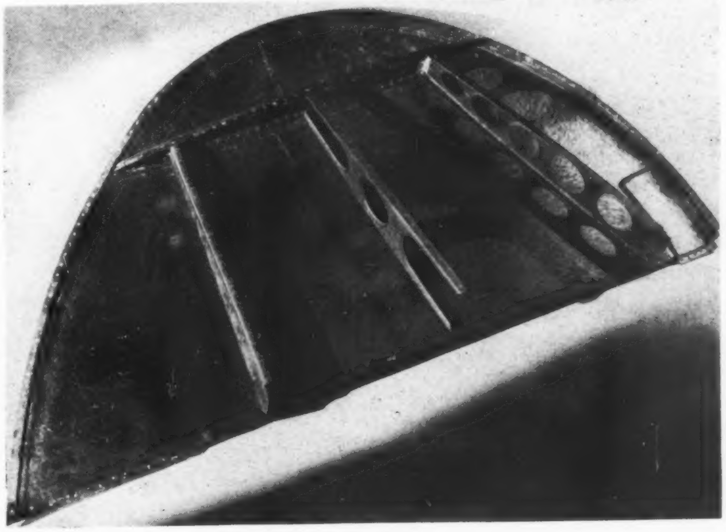
Creep: As shown in *Fig.* 8, creep characteristics and the resulting permanent set of plastic materials are very much dependent upon temperature. In fact no other physical property of plastics changes so much with temperature as creep, particularly as temperatures go above 120 degrees Fahr. This indicates that in the application of plastic materials, especially thermoplastics, at temperatures above 120 degrees Fahr. designers must anticipate an increasing rate of creep. Elastic properties of the material as evidenced by the modulus may not suffer much change, but the continued deformation upon sustained application of stress should be carefully analyzed. Creep data in *Fig.* 8 were obtained by deflection of a simple cantilever beam under a constant load.

Certain problems should be anticipated in designs involving plastics in conjunction with other materials when temperature effects are to be taken into account. In general, plastics have a higher coefficient of expansion or contraction than metals. Some designs in plastics have featured elaborate inserts of metal parts which upon exposure to low temperatures encountered in high-altitude flying have developed cracks. Internal stresses due to differences in thermal coefficients may seriously limit the usefulness of certain designs.

In considering the applications of plastics or resin adhesives to aircraft, not only should the effects of low and high temperatures be studied, but also the effects of extreme temperature changes in the space of a few minutes. For example, in traveling from the cold, dry atmospheres of high altitudes to the warm, moist atmospheres of low altitudes a number of changes may occur. These affect the electrical insulation characteristics as well as the physical dimensions. The part shown in *Fig.* 9 is an example of a successful application of a molded plastic in this type of service.

Scanning the field for IDEAS

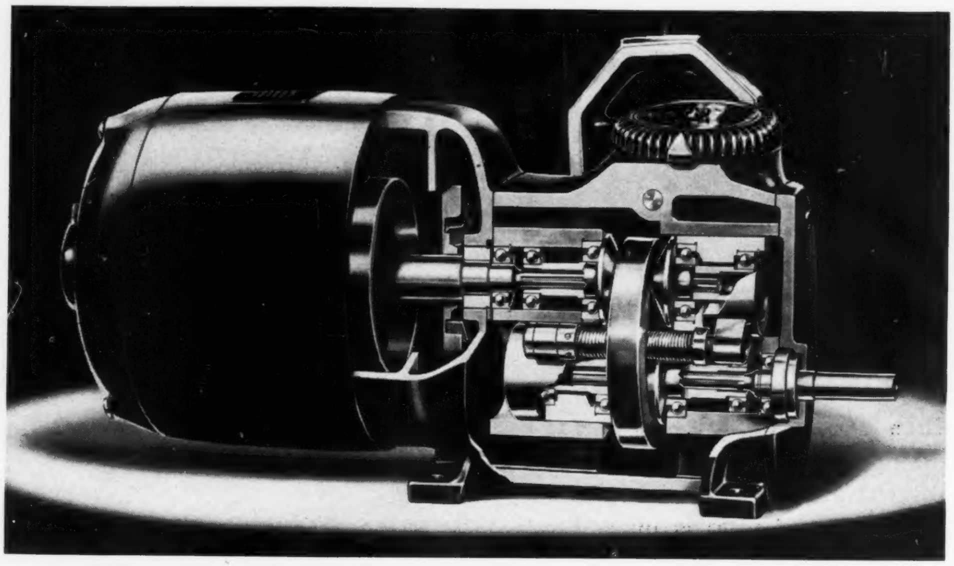
LAMINATED paper plastics show such promise that "planes of paper" may be a partial answer to the materials shortage facing the aircraft industry. Available in almost unlimited quantities, a special wood pulp is utilized for the paper which is impregnated with phenolic resins. This is formed and cured under heat and pressure. Molding is done at 250 pounds per square inch instead of the usual 1000 to 2000 pounds per square inch, allowing the use of relatively inexpensive zinc-alloy dies. These may be repeatedly remelted as design changes occur.



This new method, developed by McDonnell Aircraft Corp. and the Forest Products Laboratory, greatly simplifies construction as typified by the illustrations at right. Wing-tip construction is shown in the top illustration with the skin taken off to reveal the structure. Only thirteen parts are used as compared to ninety-six when fabricated of aluminum. Below are miscellaneous wing tip ribs, formed from impregnated paper blanks in one operation as contrasted with nineteen parts for plywood ribs of this type.

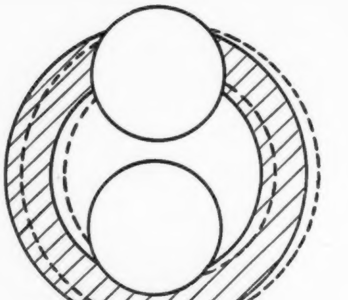
Other advantages of paper plastics include: Smooth surface obviating finishing and coating, greater resistance to abrasion and denting than aluminum, adaptability to double curvature forms without special treatment, and ease of varying thickness of sections through building up laminations as required to obtain maximum strength-weight ratios.

Ring-and cone design of an infinitely variable speed drive utilizes a steel ring between two sets of variable-diameter cones to provide maintained, constant speeds. Conceived by the Master Electric Co., this compact drive is so designed that the portion of the ring which makes contact with the cones is not a flat surface but a radius, giving a small area of actual contact. Size of this area varies with the elastic deformation of the surfaces caused by variations in the contact pressure resulting from loading conditions, similar to the action which takes place in ball bearings insofar as contact between the balls and races is



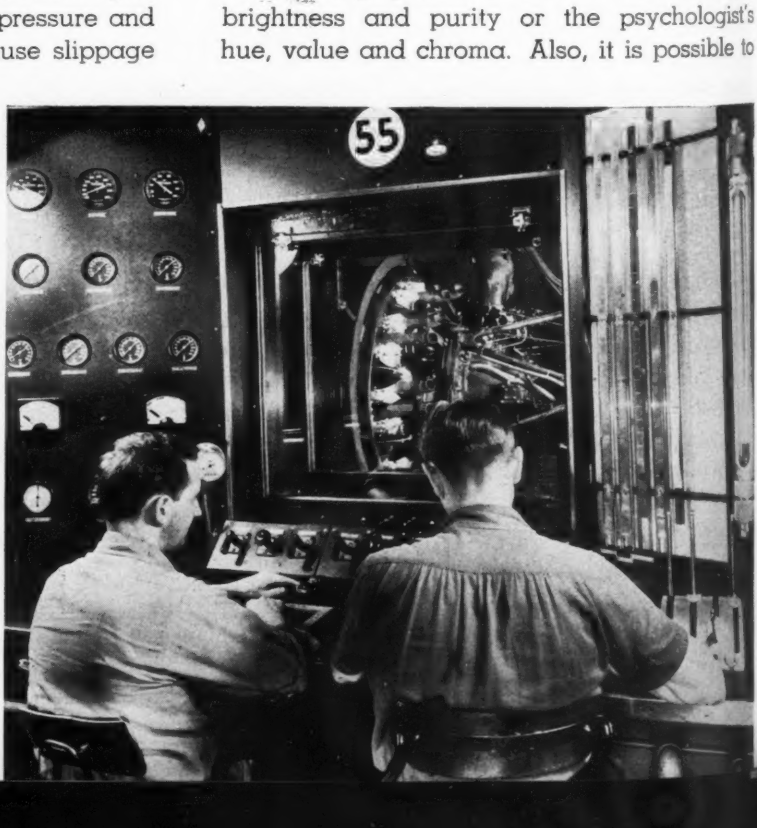
concerned.

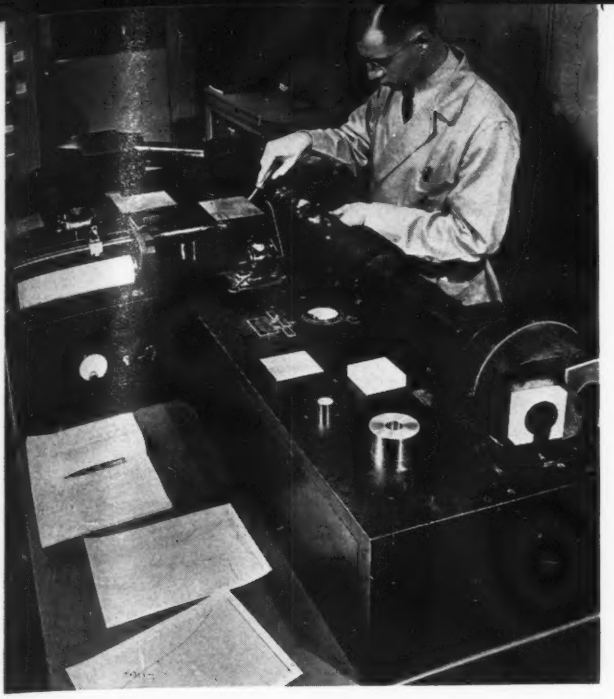
Basic principle of operation for the unit shown in the sectional photograph, above, depends upon a wedging action between the cones and ring. The schematic drawing illustrates this action. No-load position of ring is shown by the solid lines, loaded position by the dotted lines. As load increases, wedging is increased by the ring tending to climb or crowd into the cones, much like the action of V-velts. In this way traction is increased with higher loads without the need for high preloaded design. The spring shown in the photograph is an adjustment to compensate for accumulated manufacturing tolerances. In effect it produces a slight initial preloading but the actual load-carrying capacity is dependent upon the wedging action to increase the contact pressure and thus the torque-transmitting capacity. Because slippage would cause wear, the mechanism is designed so that positive metallic traction is obtained within the designed rating.



Power producing tests of aircraft engines, right, puts large amounts of energy back to work. Previously wasted by turning a propeller, engine power is utilized to generate electricity which is fed into the plant power system. Developed by engineers of Pratt & Whitney Aircraft and General Electric, this type of power recovery system has been installed widely, saving several million kilowatt-hours per month. Lines run from engine to dials and indicators within a sound-proofed booth where operators note the various readings to determine the engine's performance. A synchronous or induction generator is used as the load for the engine under test, instead of a special propeller. In a synchronous test stand a hydraulic or magnetic slip coupling ties together the variable speed of the engine and the constant speed of the synchronous machine. In an induction test stand, the generator speed varies with that of the engine so that a slip coupling need not be used to maintain synchronous speed.

New standard colors are expected to eliminate much of the existing confusion in matching colors, especially where parts are produced at different plants for assembly at a remote location. Objective of the new American War standard is to reduce to a common language the results of years of technical developments in the measurement of color so that it can be specified in terms that mean the same in all industries. The standard provides a common method to identify color by means of three basic elements, either the physicist's dominant wave length, brightness and purity or the psychologist's hue, value and chroma. Also, it is possible to



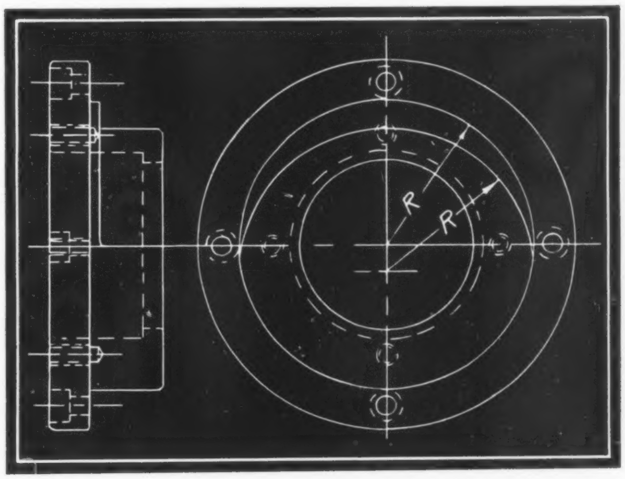


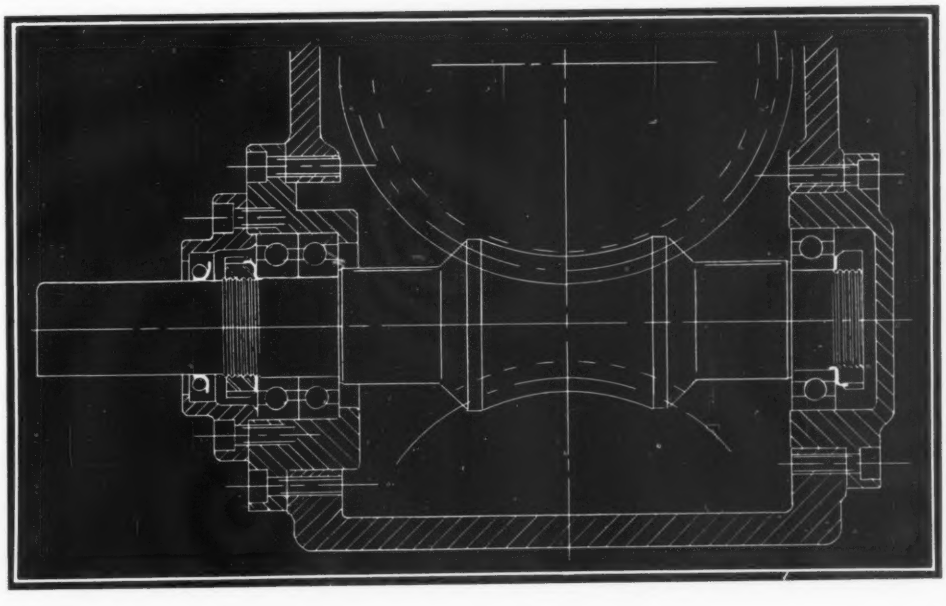
translate from one system to the other. Basic instrument for the standardization and for analyzing color samples is the spectrophotometer, one type of which is shown above. It analyzes color in terms of percentage of light reflected or transmitted by the color. A secondary standard recognizes the samples in the 1929 "Munsell Book of Color" which already has been calibrated in terms of the fundamental standard.

Accuracy of alignment, simplified reassembly, and adequate strength are provided in the gear assembly shown in the drawings at right. Based on the provision of a relieved surface on the pinion-shaft bearing retainer, this method was devised by the Michigan Tool Co. to move the pinion out of engagement with the gear and permit sliding the pinion and shaft endwise out of the housing. Such a design is particularly valuable when gears of the double-enveloping or globoidal forms are used. Another useful application is when conventional worm gearing is employed and the worm shaft is provided with large diameter bearing flanges. It also makes possible the general use of shafts of equal or larger diameter than that of the worm or pinion.

Method of removing the pinion and shaft from the housing in no way decreases the ability of the assembly to resist either the end thrust or separating force incident to worm and gear assemblies of this type. The sectional drawing, bottom, shows a pinion and shaft assembled in normal contact with the gear. Drive-end bearing retainer, below, has an eccentrically relieved surface for 180 degrees of its circumference. Rotation of the retainer through this angle permits lowering the drive end of the shaft by an amount equal to the distance between the centers whence the two radii are struck. The retainer, however, must be slightly withdrawn from the housing before it can rotate on the relieved surface. This rotation permits disengagement of the gear teeth sufficiently to permit withdrawal by slight rotation, sufficiently clearing the gear in the "dropped" position.

In this way a simple assembly, using a minimum opening in the housing to increase strength, is provided which assures accurate realignment after disassembly for inspection or service of designs where pinions cannot be slid or rotated into engagement with their gears on operating centers.





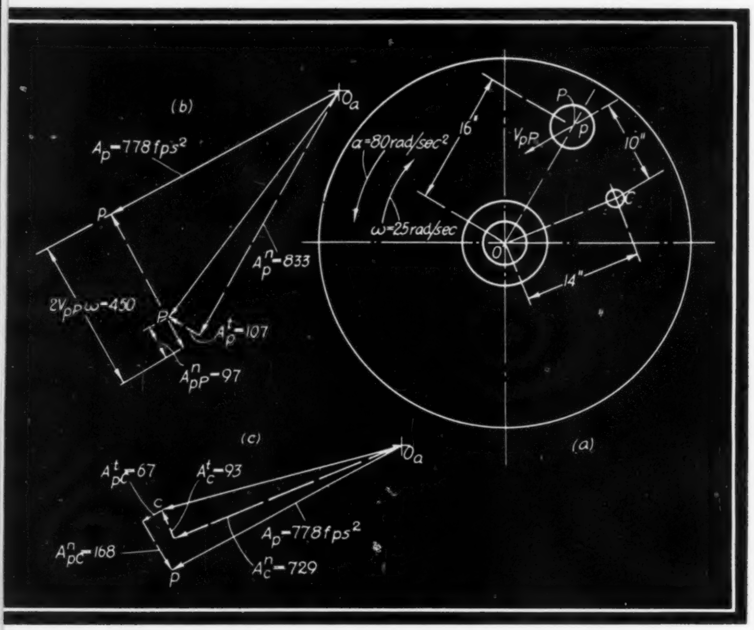


Fig. 6—Movement of governor weight with respect to rotating flywheel involves Coriolis component

IN THE first installment of this article the fundamental relationships of position, velocity, and acceleration were developed. In the generalized treatment there was determined a "compound supplementary component" of acceleration equal to $2V_{pP}\omega$, known as the Coriolis component. This component is equal to zero in some instances but has value when one point moves along a path on a rotating body. It may have an important effect upon the resultant acceleration of the point, as will be demonstrated in the examples to follow.

The essential facts to remember when computing the Coriolis component are:

1. p and P are *coincident* points, p tracing a *known path* on the link containing P.
2. V_{pP} is the velocity of p relative to P, that is, the vector difference $V_p \rightarrow V_P$. The direction of V_{pP}, as well as the magnitude, is important since upon it depends the direction of the Coriolis acceleration.
3. The V_{pP} vector, when rotated 90 degrees about its origin in the direction of ω, points in the direction of the Coriolis acceleration.
4. ω is the absolute angular velocity of the link containing P, it is, therefore, *the angular velocity of the path.*

EXAMPLE 1: Application of Coriolis' law of acceleration will first be illustrated by the following problem. The flywheel shown schematically in *Fig. 6a* is rotating clockwise at 25 radians per second and decelerating at the rate of 80 radians per second per second. Center of the governor weight, p, is assumed to be moving inward at a uniform speed of 9 feet per second relative to the coincident point, P, on the flywheel. The governor weight is pivoted on the flywheel at C; therefore the path of p relative to the flywheel is a circular arc with center C and radius Cp. The problem is to compute the total acceleration of point p. For this acceleration the expression is

$$A_p = A_P + \rightarrow A_{pP}$$

where $A_P = A_{PO} = A^n_{PO} + \rightarrow A^t_{PO}$

How Accelerati

Part II

By A. S. Hall and E. S. Ault
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and $\quad A_{pP} = A^n_{pP} + \rightarrow A^t_{pP} + \rightarrow 2V_{pP}\omega$

The last expression is Coriolis' law for the relative acceleration of coincident points.

The following computations are made, taking the necessary dimensions from the drawing:

$A^n_{PO} = [OP]\omega^2 = (16/12)(25)^2 = 833$ feet per second per second, directed from P toward O

$A^t_{PO} = [OP]\alpha = (16/12)(80) = 107$ feet per second per second, directed perpendicular to OP in a counterclockwise sense about O

$A^n_{pP} = V^2_{pP}/[Cp] = (9)^2/(10/12) = 97$ feet per second per second, directed from p toward C

$A^t_{pP} = O$ since it was assumed that V_{pP} was uniform

$2V_{pP}\omega = 2\ (9)\ (25) = 450$ feet per second per second, in the direction C to p, determined by rotating the V_{pP} vector 90 degrees about its origin in the direction of ω (clockwise).

Total acceleration of p can now be determined by choosing a suitable scale and adding graphically the various components computed above. This has been done at b in *Fig. 6.* Starting at point O_a, A^n_p and A^t_p were first added to give the acceleration of P, represented by the vector O_aP. To this were added the vectors A^n_{pP} and $2V_{pP}\omega$. Finally the total acceleration of the governor weight is represented by the vector O_ap. The scaled value in this problem is 778 feet per second per second.

As a check on the above method the problem may be solved in another manner by writing:

$$\begin{aligned} A_p &= A_C + \rightarrow A_{pC} \\ &= A^n_C + \rightarrow A^t_C + \rightarrow A^n_{pC} + \rightarrow A^t_{pC} \\ &= [OC]\omega^2 + \rightarrow [OC]\alpha \quad + \rightarrow [Cp]\omega'^2 \\ &\quad + \rightarrow [Cp]\alpha' \end{aligned}$$

where ω' and α' are, respectively, the *absolute* angular velocity and angular acceleration of Cp, the arm connecting the governor weight to its pivot point, C. It will be recalled that $V_{pP} = [Cp](\omega' - \omega)$. In this case $(\omega' - \omega) = V_{pP}/[Cp] = 9/(10/12) = 10.8$ radians per second counterclockwise. Since $\omega = 25$ radians per second clockwise, $\omega' = 25 - 10.8 = 14.2$ radians per

Analysis Can Be Improved

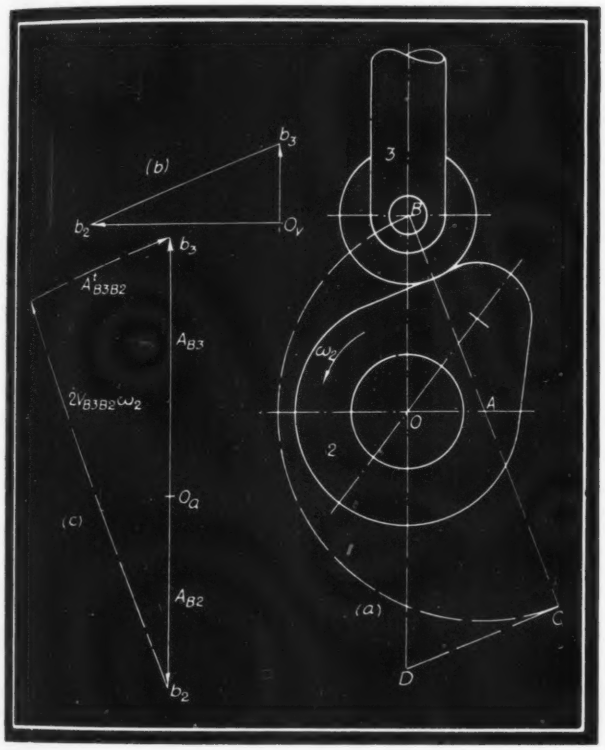


Fig. 7—Point B on follower has straight-line motion relative to point B on extended cam, creating Coriolis acceleration component at right angles to path in direction ω_2

second clockwise. Also, $A^t_{pP} = [Cp](\alpha' - \alpha)$, but in this problem $A^t_{pP} = 0$, hence $\alpha' = \alpha = 80$ radians per second per second counterclockwise.

The terms in the acceleration vector equation become:

$[OC]\omega^2 = (14/12)(25)^2 = 729$ feet per second per second, directed from C toward O

$[OC]\alpha = (14/12)(80) = 93$ feet per second per second, directed normal to OC in a counterclockwise sense about O

$[Cp]\omega'^2 = (10/12)(14.2)^2 = 168$ feet per second per second, directed from p toward C

$[Cp]\alpha' = (10/12)(80) = 67$ feet per second per second, directed normal to Cp in a counterclockwise sense about C.

Addition of these vectors is shown at c in *Fig.* 6. The result for A_p is the same in both direction and magnitude as by the previous method.

In general, the acceleration of any point may be expressed either in terms of the acceleration of the coincident point on another body or in terms of the acceleration of the center of curvature of the path traced on that body. The first involves the Coriolis component; the second does not. The problem just completed illustrates both methods of solution. In many problems the engineer can make his own choice of procedure. However, when the path traced by the moving point is a straight line or has instantaneously an infinite radius of curvature, then the center of curvature is unavailable and Coriolis' law must be employed. The next three examples are cases of this type.

EXAMPLE 2: *Fig. 7a* shows a tangent cam rotating at a uniform rate, ω_2, with a reciprocating roller follower in contact with the tangent portion of the cam. Noting that point B_3, the center of the roller, at that time traces a straight line path on the cam, the solution for the acceleration of the follower proceeds as follows.

Velocity of B_3 is first found, writing $V_{B_3} = V_{B_2} \mathrel{+\!\!\rightarrow} V_{B_3B_2}$, where B_2 is the point of the extended cam coincident with B_3 on the follower. This equation is solved

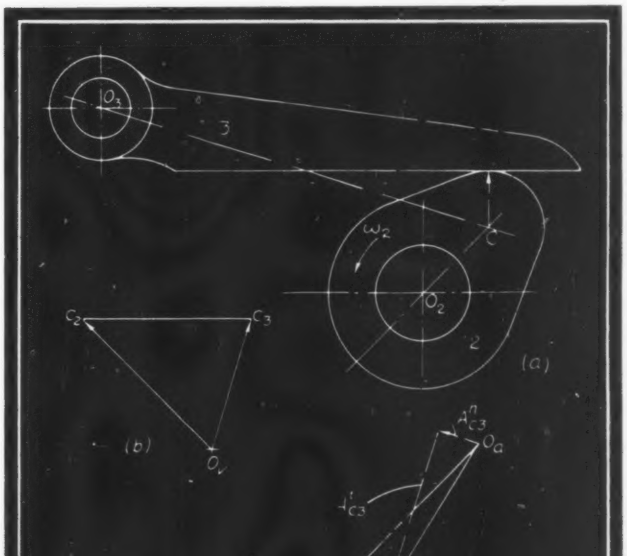


Fig. 8—Center of curvature C of cam profile has straight-line motion relative to point C on extended follower, creating Coriolis acceleration component at right angles to path in direction of ω_3

by constructing the velocity polygon shown at *b* in *Fig.* 7. $O_v b_2$ is the known velocity of B_2 drawn to a suitable scale. From b_2 a line is drawn in the direction of $V_{B_3B_2}$, parallel to the face of the cam. From O_v a line is drawn in the direction of motion of the follower. Then $b_2 b_3$ represents the velocity of B_3 relative to B_2, directed upward to the right.

Next the acceleration of B_3 is expressed in terms of the acceleration of B_2 and the relative acceleration between these two points:

$$\begin{aligned} A_{B_3} &= A_{B_2} \mathrel{+\!\!\rightarrow} A_{B_3B_2} \\ &= A^n_{B_2} \mathrel{+\!\!\rightarrow} A^t_{B_2} \mathrel{+\!\!\rightarrow} A^n_{B_3B_2} \mathrel{+\!\!\rightarrow} A^t_{B_3B_2} \\ &\quad \mathrel{+\!\!\rightarrow} 2V_{B_3B_2}\omega_2 \end{aligned}$$

$A^t_{B_2}$ = 0 since the speed of the cam is uniform

$A^n_{B_3B_2}$ = 0 because the path traced on the cam by B_3 has an infinite radius of curvature

$A^n_{B_2}$ = $[OB]\omega_2^2$, computed

$A^t_{B_3B_2}$ is parallel to the cam surface (parallel to $V_{B_3B_2}$) but is unknown in magnitude

$2V_{B_3B_2}\omega_2$ is computed using the value of $V_{B_3B_2}$ scaled from the velocity polygon. This vector will be normal to the cam surface with sense upward to the left.

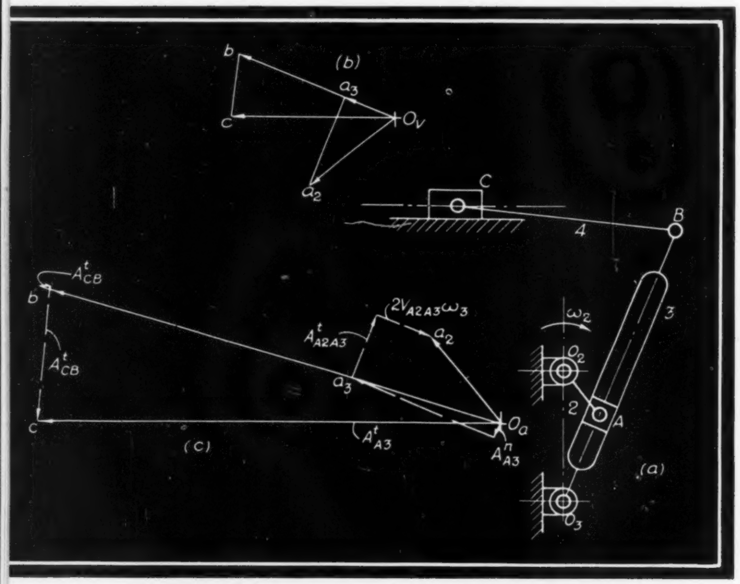


Fig. 9—Point A on crank has straight-line velocity with respect to point A on oscillating arm of shaper mechanism, creating Coriolis acceleration component at right angles to path in direction of ω_3

The acceleration diagram is now constructed as shown at *c* in *Fig.* 7. From the pole point O_a is laid out the vector representing A_{B_2}. To this is added the vector $2V_{B_3B_2}\omega_2$ and from the tip a line is drawn in the direction of $A^t_{B_3B_2}$. The tip of the A_{B_3} vector will be at the intersection of this line and a line representing the acceleration of B_3 drawn through O_a in the direction of motion of the follower.

The scales used in this problem were chosen such that the length *OB* on the drawing represents both the velocity and the acceleration of point B_2. With these scales the construction could have been made directly on the drawing without intermediate computations. This construction is shown by broken lines in *Fig.* 7*a*. Triangles *OAB* and *BCD* are exact duplicates of the velocity and acceleration

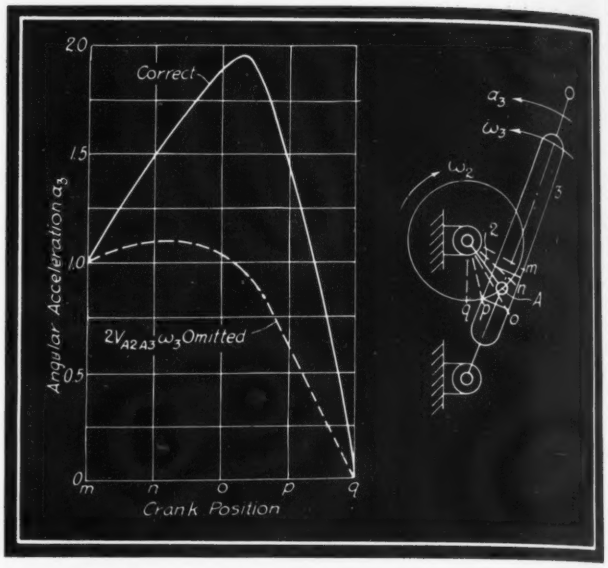


Fig. 10—Effect of omitting Coriolis component in the acceleration analysis of a shaper mechanism is shown by the curves plotted on a base of crank angle

polygons revolved 90 and 180 degrees, respectively.

In Examples 1 and 2 a point on the link for which acceleration was to be determined traced a path of known curvature on the link with known acceleration. This is not always the case.

EXAMPLE 3: In the combination of cam and pivoted flat follower shown in *Fig.* 8*a* it is not at all evident what path is traced on the cam by any point of the follower. On the other hand, it is known that point *C*, the center of curvature of the cam outline at its point of contact with the follower, traces on the follower a path of infinite radius. Unless the cam outline is composed of circular arcs the path will not be a straight line. Nevertheless it can be demonstrated that its radius at the particular point under consideration in this illustration will be infinite. In solving for the acceleration of the follower it is therefore most convenient to deal with point C_2 of the cam and the coincident point C_3 of the follower extended. For these points the velocity diagram is constructed as shown at *b* in *Fig.* 8. The absolute velocity of C_2 is computed and drawn in its proper direction from point O_v. From its tip a line is then drawn in the direction of the relative velocity of C_3 to C_2 (parallel to the face of the follower). The intersection of this line and a line through O_v in the direction of the velocity of C_3 normal to O_3C) locates tip of V_{C_3} vector.

Since it is the path of C_2 rather than C_3 which is known, the acceleration equation is first written,

$$A_{C_2} = A_{C_3} \mathrel{+\!\!\rightarrow} A_{C_2C_3}$$

then rearranged to read

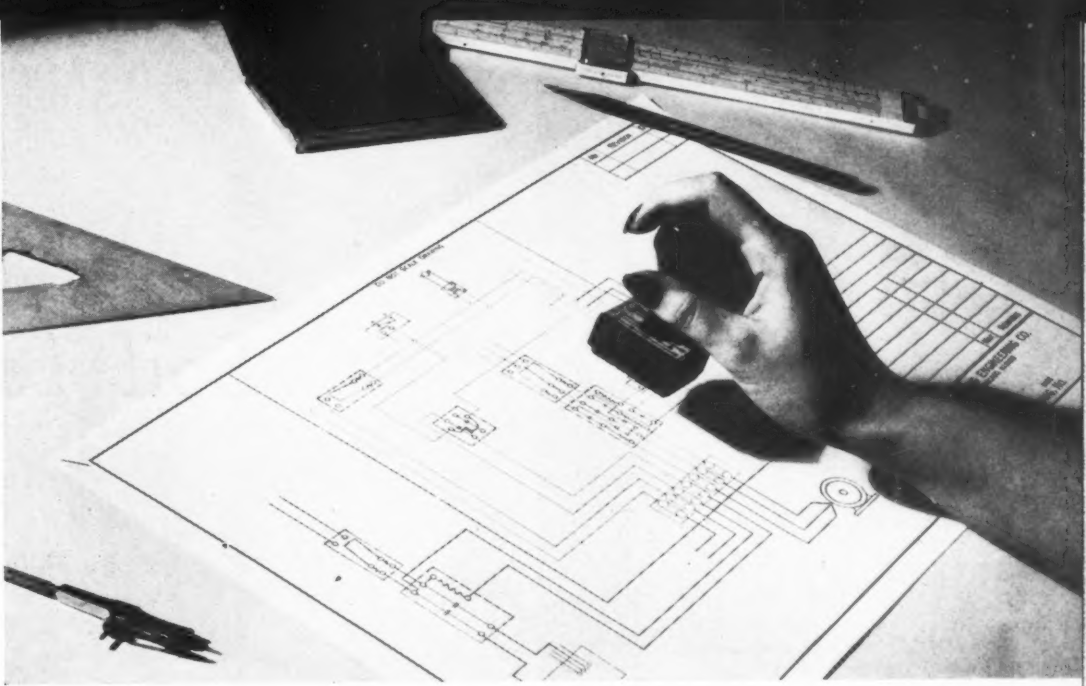
$$\begin{aligned} A_{C_3} &= A_{C_2} \rightarrow A_{C_2C_3} \\ &= A^n_{C_2} \mathrel{+\!\!\rightarrow} A^t_{C_2} \rightarrow A^n_{C_2C_3} \\ &\quad \rightarrow A^t_{C_2C_3} \mathrel{-\!\!\rightarrow} 2V_{C_2C_3}\omega_3 \end{aligned}$$

where $A^t_{C_2}$ = 0, since ω_2 is uniform

$A^n_{C_2C_3}$ = 0, since the radius of the path is infinite

$A^n_{C_2}$ = $[O_2C]\omega_2^2$, computed, directed from *C* toward O_2

(*Continued on Page* 168)



Rubber stamps greatly reduce draftsman's time in drawing wiring diagram of furnace for heat treatment of gun parts

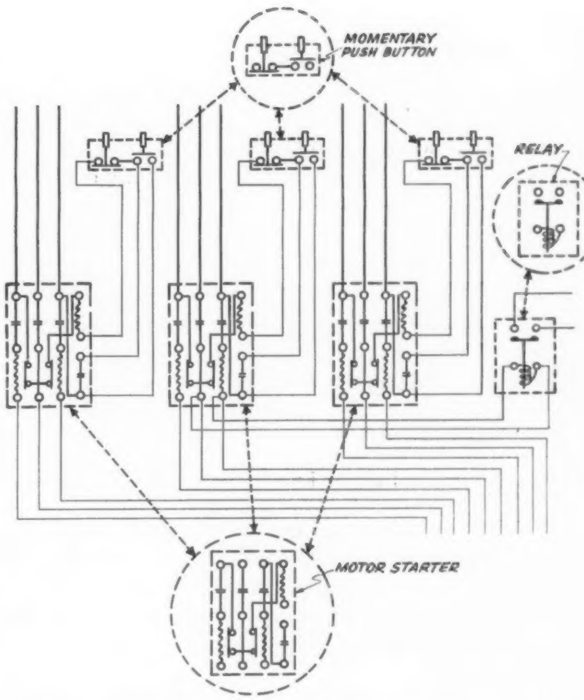
Stamps Facilitate Drafting Work

TODAY when maximum efficiency is required of limited personnel, it is important to utilize as many time-saving methods as may practically be employed. Especially is this true in the drafting room where tedious hours may be consumed in drawing parts which can be standardized and effectively portrayed by other methods. Typical of the possibilities is a method in use at the Lindberg Engineering Co. which employs rubber stamps for standard parts of schematic drawings. In addition to conserving time in the drafting room, this method aids all along the line.

Practically all engineering departments use symbols of some sort for switches, pipes, valves, etc., to simplify the making and reading of shop, assembly, erection or instruction drawings. Also, these symbols are often repeated many times on the same drawing. Size of the symbols, or schematics, may be standardized for standard-size drawings to allow the use of rubber stamps. A high degree of uniformity exists between the various drawings employing these symbols and also between the same symbols on any one drawing, facilitating reading and minimizing errors in interpretation. For electrical schematics as shown in the lower illustration, wiring errors are reduced because the terminals are always correct for connections.

Additional uses for rubber stamps in the same company are being found weekly. The highest price paid to date for such a stamp is $7.50 and it is estimated that enough time has been saved to pay for the stamp on a single drawing. Some of the symbols being used include: Mercury switches, motors, controls, connector blocks, valves, governors, nameplates and solenoids.

During the past months a considerable number of the company's draftsmen has been taken into the armed forces, particularly detail men, and it has been necessary to train girls quickly. Among this training group the saving in time



Section of a wiring diagram for a conveyor furnace to harden aircraft parts. Stamps were utilized in the production of this drawing, indicating the neatness and uniformity possible

through the use of rubber stamps has been tremendous.

In brief, this drafing aid helps turn out war material faster because it reduces routine work and the possibility of errors, while at the same time facilitating production because of better and more uniform drawings.

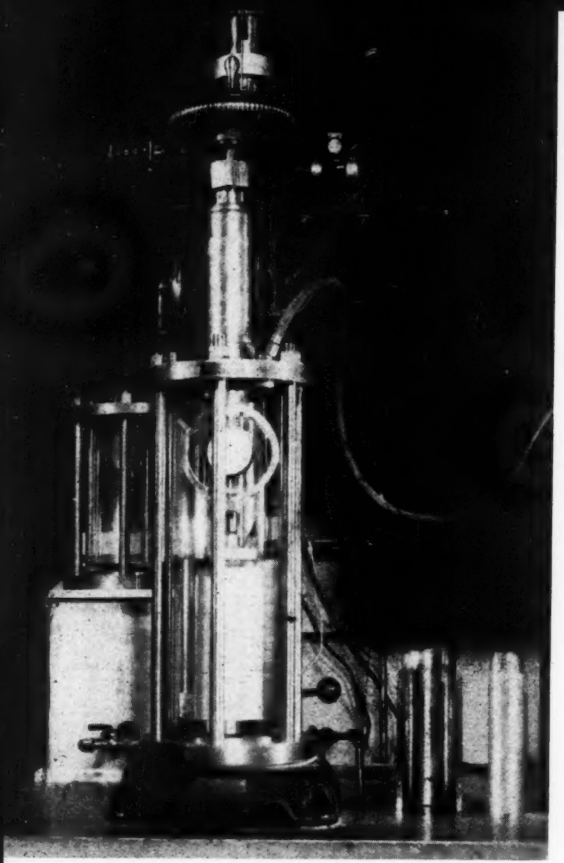


Fig. 1—Front view of soil-testing machine with sample and proving ring in place ready for test

Soil Tester Aids

By Philip O. Malmberg

ARMY engineers must work at high speed, often under fire, constructing temporary bridges, roads, etc., capable of carrying heavy military machines and troops. To accomplish these feats the engineers must be thoroughly familiar with soils and the results to be expected from different varieties. On the battlefield no time is available for testing and the success or failure of temporary earthwork structures depends on the accumulation of a store of information based on extensive laboratory tests covering the mechanical properties of all types of coils.

Most important property of soils for engineering purposes is the resistance to shear, for the measurement of which a testing machine, discussed in this article, was recently designed and built at the U. S. Engineer office, Providence, R. I. Though the design is partly based on apparatus developed at the Massachusetts Institute of Technology, the new machine is not only much larger but also specially designed for use where many tests are performed daily.

Basic Design Requirements of Testing Machine

In the triaxial shear test for which the machine was designed a cylindrical sample of water-saturated soil is sealed in a thin rubber membrane and exposed to a controlled hydrostatic pressure within a transparent pressure chamber, *Fig.* 1. At the same time an axial load is gradually applied until the specimen fails by shear as in *Fig.* 2, or bulges excessively.

Basic requirements for the design of a production machine to perform this test were laid down as follows:

1. Maximum load capacity 3000 pounds
2. Maximum hydrostatic pressure 250 pounds per square inch
3. Sample size 2.8-inch diameter by 8 inches high
4. Maximum travel of plunger 3½-inches
5. Means of measuring applied load directly on the sample
6. Means of measuring the strain directly
7. Transparent pressure chamber for viewing sample under test
8. Absolute pressure tightness so that air or water can be used with equal success as the pressure medium
9. Electrically and mechanically operated
10. Location devices to enable rapid assembly and practically automatic alignment during sample set up
11. Ease of operation and flexibility
12. Parts in contact with water, gas and soils to be made of corrosion-resisting materials, other parts to be cast iron finished with black crinkle enamel.

Shown in *Figs.* 1 and 3 is the mechanical arrangement of the machine which consists principally of six parts: Sample base, pressure chamber, loading head, proving ring assembly, raising mechanism, and pressure reser-

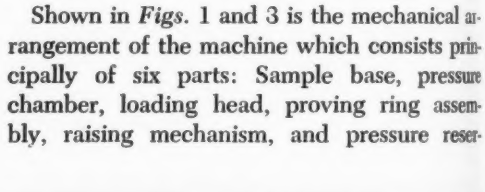


Fig. 2—Soil sample enclosed in rubber membrane, after test, showing failure plane along which the soil sheared

Aids by Engineers

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gas and soils materials, other black crinkle

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voir. The soil sample, encased in the rubber membrane, is assembled between the sample base and cap, porous stones at top and bottom allowing water drainage but no escape of soil. Plunger of the loading head applies a downward load through the proving ring which measures the applied load.

Sample base on which the soil specimen rests during test has two ports, one connected to the sample, below the lower porous stone (*Fig.* 3), the other connected to the pressure chamber on the outside of the specimen. The first port is used to apply vacuum to the specimen during saturation preliminary to the test, while the second connects the pressure chamber with a water storage reservoir, visible in *Fig.* 1. to the left of and behind the tester itself. A watertight rubber membrane is connected to the sample base by a special sealing clamp, insuring that the sample does not come in contact with the water or gas that surrounds it. To cut down set-up time, dowel pins are provided to locate the base correctly on the loading platform.

Pressure Chamber Is Plastic

Pressure chamber, *Figs.* 1 and 3, is transparent plastic cylinder. Because of frequent handling, the use of glass was considered but discarded. The particular tubing used was chosen because it was the largest commercially available, and the entire machine was designed around this size. The pressure chamber houses the sample, the pressure medium (water and nitrogen or water alone), and the proving ring assembly. Specially molded rubber gaskets at top and bottom insure watertightness, also aid in correctly centering the plastic cylinder during set-up. The whole unit is clamped together by six tie rods.

After assembly, water is admitted to the pressure chamber until the sample is completely submerged. Nitrogen from a pressure storage cylinder is then admitted at the top

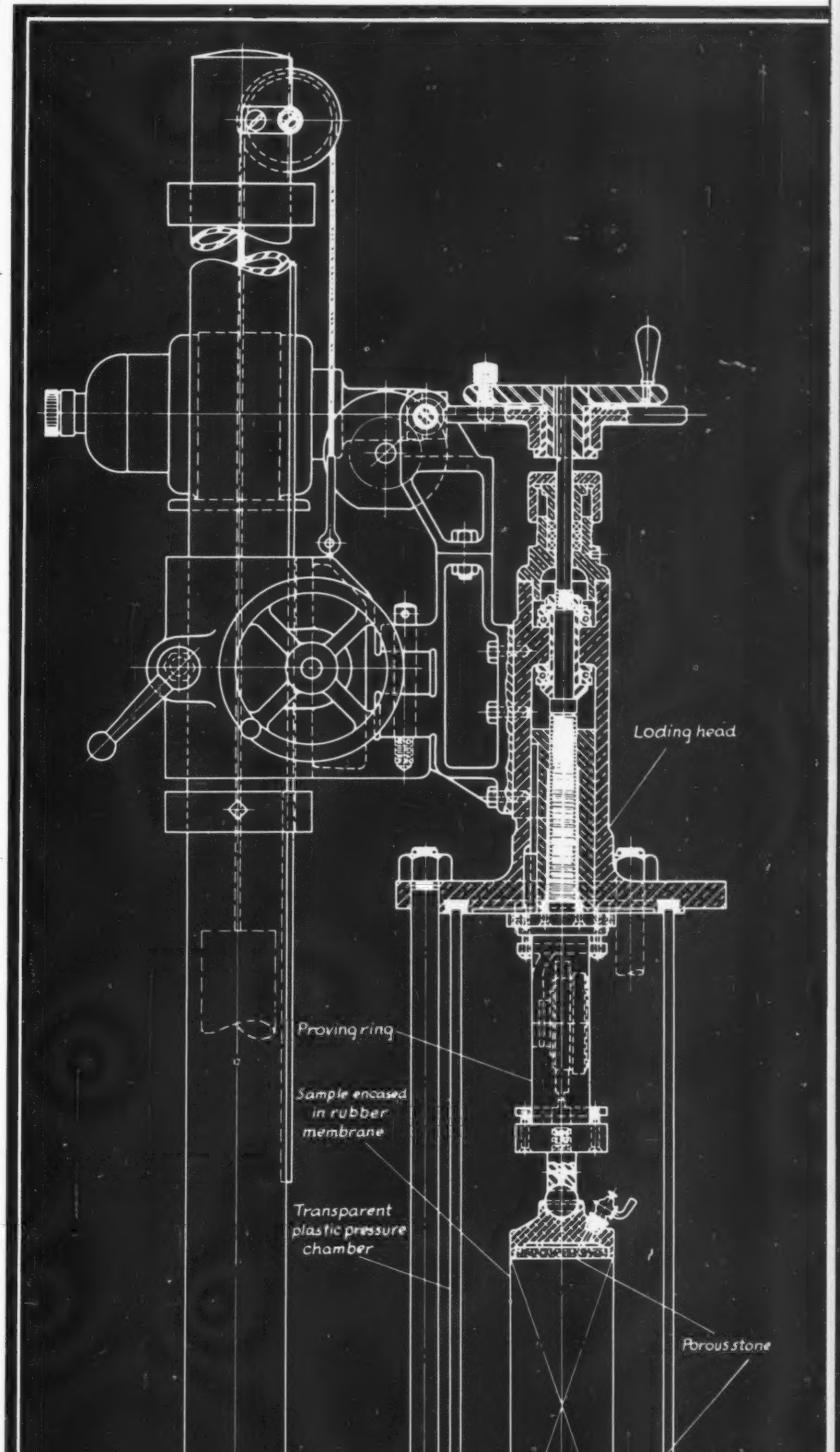


Fig. 3 — Right — Side elevation shows mechanism of loading head and details of the sealing of the pressure chamber

of the pressure chamber until the desired pressure is exerted on top of the water, thus providing the hydrostatic pressure on the specimen necessary for this test.

Loading head, *Figs*. 3 and 4, contains the lead screw and plunger on which the proving ring is fastened. Leakage of nitrogen past the screw or thrust bearing sleeves is prevented by a stuffing box at the top of the screw. Stringent requirements of pressure-tightness made neces-

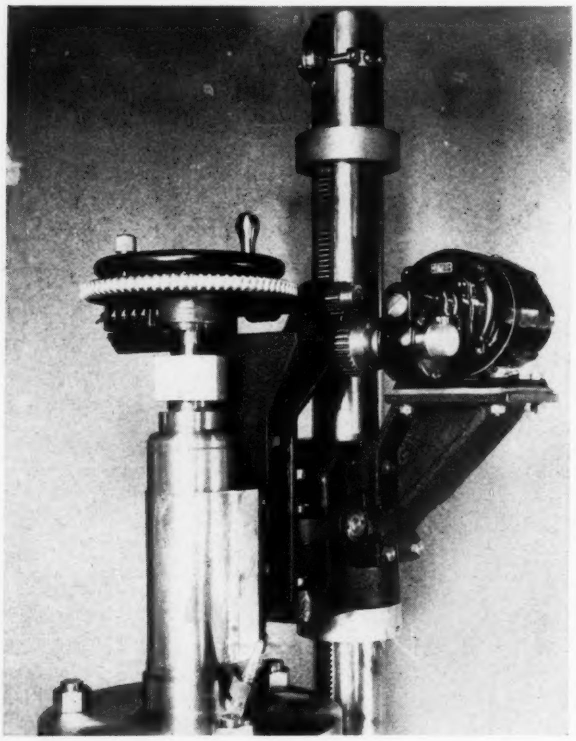


Fig. 4—Close-up view shows driving mechanism for loading head, also collars on vertical column limiting travel of the head

sary the specification of complete freedom from porosity in the head and sample base.

Lead screw is actuated by a variable-speed motor driving through a gear train and a worm and wormwheel. The strain on the specimen is equal to the downward movement of the plunger and is directly measured by a revolution counter attached to the worm shaft, *Fig*. 1. Each revolution of the counter is equivalent to a deflection of .001-inch, and rate of strain can be adjusted within limits from .0125-inch per minute to .25-inch per minute. Total load that may be applied is 3000 pounds with an additional allowance of 1/3 for overload. The handwheel above the wormwheel, *Fig*. 4, is used for manual adjustment of the plunger prior to the test. A locking pin serves to connect and disconnect the wormwheel and handwheel.

Functions of the proving ring and dial indicator, *Fig*. 5, are to measure the axial load applied to the top of the sample. Because of its location between the loading plunger and the sample the proving ring measures only the actual load on the sample, no friction errors being present. Load applied across a diameter of the proving ring causes elastic deflection which is measured with a dial gage reading to 1/10,000-inch. Ring is ground to calculated dimensions and calibrated so that a unit deflection is equivalent to a known load. Accuracy of this type of ring is plus or minus one per cent at as low as one-fifth of capacity, which is well within the accuracy of the other measurements of the test. Rings of two capacities were made, one for loads up to 1000 pounds maximum with two-pound readings per division on the dial, and the other for 3000 pounds maximum with ten-pound readings per dial division. The rings are SAE 6145 steel, heat treated to an ultimate tensile strength of 180,000 pounds per square inch and yield point 160,000 pounds per square inch.

Raising mechanism is connected to the loading head by means of two removable coupling pins, *Fig*. 4. By

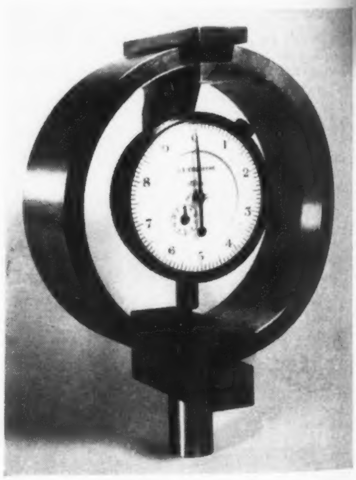
Relative Costs

Preliminary cost, study, research, analysis, layouts, sketches, production of drawings, formulation of specifications, inspection during fabrication	33.2%
Machine and equipment	59.6%
Supporting table and foundation	7.2%
Total cost of installation	100.0%

this arrangement it is possible to detach the testing machine if necessary and use it as a portable device elsewhere. Functions of the raising mechanism are to lift the heavy loading head out of the way of the operator during sample set up and to assure a positive means of alignment of the loading head with the sample. This is important because any misalignment axially will tend to bulge the sample, resulting in an inaccurate test.

The raising is accomplished by a handwheel, pinion and rack attached to the vertical column, *Figs*. 1 and 3. Collars on the column, *Fig*. 4, locate the operating and stand-

Fig. 5—Dial readings are proportional to load applied on specimen through the proving ring



by positions of the loading head. A flexible wire cable attached to the unit runs over a ball bearing pulley at the top of the column, then down inside to a lead counterweight. This counterweight is slightly heavier than the unit, allowing the loading head to rack up more easily and eliminating the danger of sliding down suddenly and injuring the operator or spoiling the test. A clamp locks the mechanism in the desired position.

While the duration of the test itself cannot be speeded up because of the necessity of adhering to standard procedure, overall testing time per sample has been considerably reduced with this machine as result of designing for quick set up.

Wartime Metallurgy Conserves Strategic Materials

Part VIII—Production Processes

By R. E. Orton and W. F. Carter
Acme Steel Co., Chicago

PREVIOUS discussions in this series have treated steel as a composition solely of iron and carbon, ignoring the other elements that are present in a commercial carbon steel. Of these other elements a few are present because of their desirable effect, others are either unavoidably present or their presence is deemed unharmful and not worth the trouble required for their removal. There is also a variety of other imperfections that distinguish a commercial steel from the pure iron-carbon alloy.

It is well to examine the actual production of iron and steel, to understand better what it would mean

Fig. 64—Top—Excellence of control and lack of impurities from heating agent enable the electric furnace to produce highest quality steel. Photo, courtesy U. S. Steel Corp.

Fig. 65—Highly stressed parts preferably should be made from fully killed steels. Above parts are high-carbon, alloy and tool steel for band-tensioning and sealing devices

to attempt to keep out these harmful elements. Unquestionably, many phases of the war effort are being hampered by unnecessary and unreasonable specifications in regard to these commercial inevitables. Appreciation of these factors on the part of specification writers would undoubtedly lead to relaxation of some unnecessarily rigid requirements. In many cases a more rapid production would be obtained by accomodation of the design to the material defects than by an insistance on an unreasonable degree of perfection.

There are a number of features of the dry chemistry of the technology of iron and steel that should be recognized. First, practically all of the reactions are reversible, and a certain set of conditions must exist for the reaction to go in the desired direction. A minimum temperature, generally near or above the fusion point, is required for any reaction; variations of the temperature above this level markedly influences the nature and the order of the reactions.

Mass also has a paramount influence. Thus, manganese has such a strong affinity for sulphur that it will remove it from iron sulphide, $Mn + FeS \rightarrow MnS + Fe$. However, if there are a thousand parts of iron to one of sulphur and just enough manganese to combine with the sulphur, a certain proportion of the FeS will remain because of the "mass effect" of the iron. In probably no case, then, would the reaction go to completion, because of the free iron liberated which then exerts its influence to restrain further action.

Controlling Extent of Reactions

However, if the MnS could be removed in some way from the sphere of influence as fast as it is formed, the reaction would go much further toward completion. If this product were a gas it would pass out to the atmosphere; if insoluble in the fused mass it would separate from the solution and perhaps float out to join the "flux". If neither of these it might be combined to a compound that would. Most commonly this last is accomplished by combining acid and basic (anhydrides) to form slags, the "salts" of dry chemistry.

Just exactly how, or to what extent, these various factors affect the reaction is not important at this time as long as the variables themselves are taken into account.

Heat required for the reduction of the oxide of iron ores common to the United States is obtained by the combustion of coke in the charge supplied to the blast furnace. By supplying a deficiency of air, carbon monoxide is generated which reduces the iron oxide to metallic iron. Besides the iron mineral in the ores there are large quantities of silica, silicates, alumina and aluminates. The last two are insoluble and when fluxed by limestone are floated out of the fused mixture. The CO tends to reduce the first two and to keep this reduction from being excessive. Limestone is supplied which calcines to CaO and serves as a base to react with the SiO_2 acid radical, carrying it out as a slag. Because of the mass effect, however, a certain amount of the silicon is reduced and appears in the iron as FeSi.

The ore will also contain oxides of manganese and phosphorus. About half of the first will be reduced and almost all of the second, and will enter into the iron. Carried in primarily with the coke is a large quantity of sulphur, a portion of which combines with the iron or manganese and dissolves in the iron. Owing to the mass of coke present a portion of it will remain as elementary carbon and enter the iron either combined as the carbide, Fe_3C or in the graphitic form.

Pig iron suitable for steel, as drawn off the blast furnace will have the following analysis:

Element	Per Cent
Carbon	3½ to 4¼
Silicon	Up to 1½
Manganese	½ to 2½
Sulphur	Up to .05
Phosphorus	Up to 1

Essentially, the conversion of pig iron into steel is the opposite of the reduction of the ore. The impurities are oxidized and usually fluxed off, as a slag, or emitted as a gas.

Sulphur Is Not Separated

In all processes the oxidizing medium is ferrous oxide FeO, supplied by the combustion of iron or reduced from mill scale or ore. Since it is soluble in the iron it is readily distributed to all parts of the bath. Manganese and silicon are thus oxidized and separate out, the FeO being reduced to Fe. Carbon is similarly removed as the gaseous monoxide CO. The sulphur is practically unaffected by such a process and, except in the electric furnace, generally remains in the metal.

Before the phosphorus can be removed practically all the silicon must have been oxidized and, in addition, have been neutralized with a base. This accounts for a major division in the processes—acid and basic. In the first the refractory in contact with the metal is acid (generally SiO_2); in the second it is basic, calcined limestone, dolomite, etc., and limestone is added to flux and neutralize. The first gives a more durable container for the metal, the second makes possible the oxidation of the phosphorus by neutralizing the SiO_2 and also P_2O_5 formed, which is strongly acid and must be neutralized to retain it in the slag.

Because of mass and temperature effects there will be residuals from all of these processes, the most troublesome of which is the oxide FeO. To remove this combined oxygen, that is, "deoxidize" the bath, manganese and silicon are added after separating the otherwise purified

metal from the slag. The carbon in some processes is caught "coming down," but in most of the lower carbon ranges it is brought to a residual value and the metal then recarburized by adding anthracite coal, pig iron, or some one of the metallurgical ferroalloys.

Steel conversion is divided into three major processes —bessemer, open hearth and electric. In the bessemer process, all the heat is supplied by the combustion of the iron and impurities and by the heat of the hot charge of pig iron which it uses. The converter itself consists of a large open pear-shaped vessel of five to thirty-ton capacity. Air is blown through fine holes in its bottom, serving to agitate the mix and to oxidize the iron, thus raising the temperature and furnishing the FeO for the other reactions.

For various metallurgical reasons, few ores used in this country are suitable for the basic bessemer and it therefore is little used. Reference to the bessemer, in general, applies to the acid process. Since no phosphorus is removed in this process nor in the blast furnace, ores must yield a phosphorus content of under about 1 per cent. Such ores therefore are classified as "bessemer ores". Other ores, suitable for the basic open-hearth process, are known as "basic ores".

The whole conversion is accomplished in 15 to 20 minutes, the reaction occurring so rapidly that control

Fig. 65—Rimmed steels are preferred for severe forming. Left to right are bomb booster adapter body, copper-plated steel shell base, .22 caliber cartridge case, and a bomb booster adapter cap

is comparatively difficult. The mass is also so violently agitated that the separation of the slag, flux and other foreign particles is poor, yielding a rather inferior product for high-grade applications but an economical product where these defects are not objectionable.

In the open hearth, heat is supplied by burning preheated air and fuel over the batch, which is contained in a shallow wide basin or "hearth" of sixty to over two-hundred tons capacity. This external addition of heat makes possible much more accurate control of the temperatures and the reactions, and makes practical the elimination of the phosphorus. Because of this last feature nearly all open-hearth plants are basic except for certain small acid units employed in the foundries primarily for remelting. Reference to the basic or the open-hearth process, therefore, usually refers to the basic open hearth.

External application of heat also makes possible the charging of cold pig and scrap steel, supplying some of the FeO by reduction directly from ore, reducing the loss of iron to the slag, and increasing the yield. Usual and preferred practice is to charge from 40 to 60 per cent scrap. The calcining of the limestone yields CO_2 gas which assists in stirring the bath and mixing in the FeO. While some sulphur may be oxidized out in the open hearth this is generally more than offset by additional sulphur from the fuel. Conversion time is some ten to twelve hours, varying considerably with the amount of scrap charged.

Absence of blowing air gives a much quieter bath with the open-hearth process than with the bessemer and, therefore, greater freedom from slag and other inclusions. External application of heat and the slowness of the process give better control over the analysis. A greater variety of raw materials may be used and a greater variety of products may be serviced.

Produces Highest Quality

Conversion in the electric furnace, *Fig.* 64, is similar to that in the open hearth except that the heat is furnished by the action of electric arcs, and practically all the FeO is obtained from mill scale or ore rather than by oxidation of the iron. Oxidation of the Mn and Si is followed by that of the phosphorus which is then directly neutralized with lime (CaO), fluxed with the addition of a small amount of ore and then tapped or raked off to prevent its returning to the bath.

Sulphur may be removed readily by the electric process. The high heat close to the arc generates calcium carbide,

$$CaO + 3C \rightarrow CaC_2 + CO$$

and then,

$$3\,\begin{matrix}FeS\\MnS\end{matrix} + 2CaO + CaC_2 \rightarrow 3\,\begin{matrix}Fe\\Mn\end{matrix} + 3CaS + 2CO$$

The CaS, being insoluble, may be fluxed out. An appreciable amount of elementary carbon being required, the desulphurization may not be carried as far in very low carbon steels as in other carbon grades. In steels of a somewhat higher carbon content the sulphur may be reduced to as low as .02 per cent commercially.

Unquestionably, the electric furnace is capable of producing the highest quality steel and is used therefore for the highest grades of alloy, high-carbon and tool steels. The ease of manipulation of the heat, the ability to carry on oxidizing, reducing or neutral operations at will, the

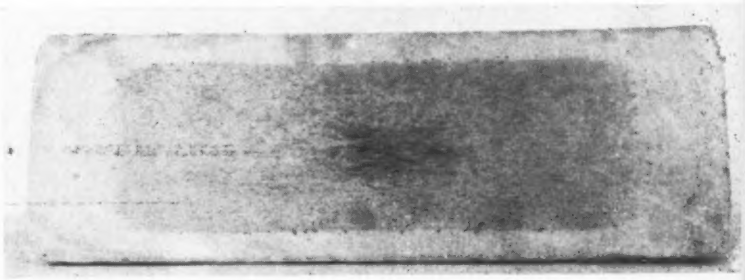


Fig. 67—Rimmed steel slab. The high-purity, low-carbon periphery exhibits high ductility and when rolled into strip forms a good surface for deep drawing and forming

cleanness of the heating agent, and the fact that the quantity of oxygen supplied to the bath is under control gives precise control of the analysis. Up to 100 per cent scrap or cold pig may be charged.

Advantages and disadvantages of these three processes of steel conversion are summarized in the accompanying tabulation:

Comparison of Steel Processes

	Advantages	Disadvantages
BESSEMER		
	Low operating cost	Phosphorus not eliminated
	Low initial investment	Sulphur not eliminated
	Low maintenance cost	High slag inclusions
	Rapidity of conversion	Poor control
	No external fuel	Utilizes little scrap or cold pig
	Low lining loss	Small heats
		Finish off in ladle
		High iron loss in slag
OPEN HEARTH		
	Uses half scrap	High initial investment
	May use cold pig	Medium operating cost
	Phosphorus may be eliminated	High maintenance cost
	Very large heats	High lining errosion
	Partial finishing in furnace	High iron loss in slag
	May use bessemer charge	Little sulphur eliminated
	Good control	Conversion is slow
		Fuel contributes impurities
ELECTRIC FURNACE		
	May use up to 100% scrap	High operating cost
	May use cold pig	High maintenance
	Bessemer or open-hearth charge	Moderately high investment
	Excellent control	Not as large units as open hearth
	Finish off in the furnace	Conversion is slow
	Elimination of phosphorus	
	Elimination of sulphur	
	Low iron loss in slag	
	Virtually complete deoxidation	
	Very low inclusions	
	No impurities from fuel	

Considerable amounts of steel are made by duplexing—partial conversion in the bessemer and finishing in the open hearth—taking advantage of the lower fuel cost of the first and the better control of the finishing operation in the second. Sometimes completion is in the electric furnace, making use of its precision control. There is little difference in the end result, the practice being dictated by economics in which the condition of the scrap market is the prime influence.

Steels Classified by Deoxidation

A broad division in steels may be made according to the deoxidation practice. If some FeO remains, a portion of it will be reduced by the carbon, evolving CO gas as the metal solidifies in the mold. A steel is fully "killed" if it has been sufficiently deoxidized to evolve no gas and lie perfectly quiet. This practice, which is generally accomplished by the use of a strong deoxidizer in the ladle, is a necessity for high-quality alloy, high-carbon or forging grade steels such as those employed in the parts shown in *Fig.* 65. A steel is "semikilled" if the deoxidation is not as complete. This is common with structural grades of steels.

In the "rimming" process deoxidation is only partial so that a large quantity of gas is evolved in the mold as the metal solidifies. It is used with low carbon steels intended for strip or sheet because of the fine surface which is obtained, giving an excellent steel for deep drawing or severe forming operations, *Fig.* 66. The brisk evolution of the gas violently agitates the metal, resulting in a skin or "rim" of clean metal, *Fig.* 67, with a center of numerous fine blow holes. Since these holes are formed by a reducing gas they will generally be welded shut in the subsequent rolling operations.

Steels as finished, then, may be expected to contain, besides the iron and carbon, varying amounts of phosphorus, sulphur, manganese and silicon from the original ore or as additive elements. Usually they also will contain aluminum, oxygen and hydrogen in the elemental state or as metallic or "metalloid" compounds. These and, to some extent, other materials will be present in such form that they cannot be considered as part of the metal but rather as inclusions serving as discontinuities in the metallic matrix. How these elements are present and their effect on the metal will be discussed in the next article.

Plastics Require More Care in Specification

COMMON faults in the utilization of plastics in ordnance equipment are inadequate redesign and the wrong choice of materials for particular applications. Failure to distinguish between various types of plastics is evident. No one would say "metals fail" because everyone realizes that "metals" is a general term and embraces a number of materials. Many engineers, however, group the entire field of plastics as one material. A review of industrial drawings will show that certain parts are to be fabricated from bronze, aluminum, zinc or molded plastic.

In many agencies where molded plastic parts are procured, little or no thought is given as to whether a component should be molded from a thermosetting compound or a thermoplastic. Little consideration is given to the fact that over eighty types of plastic materials are available for fabrication. This condition exists probably because of the newness of the industry and the rapid development of its ever-growing number of compounds. Classification of compounds for particular end uses is therefore indicated.

At present the Ordnance Department is grouping available materials according to their ability to function efficiently. A chart is being prepared for each operating branch, listing the component parts which present satisfactory applications for plastic compounds, and the materials which should be considered. For example, the small arms chart will contain a list of components such as handles, containers, and carrying cases. The materials shown on the chart will indicate approval for use. Thermosetting materials of specified physical strength, cellulose acetate butyrate, and impregnated duck will be so authorized.

It is evident that plastic compounds have the ability to meet ordnance requirements, when materials having adequate physical and chemical properties are applied to a properly designed part. In the Ordnance Department alone, the use of plastic has released over ten million pounds of aluminum and five million pounds of brass for more essential war applications. (From a paper by Capt. E. T. McBride, Ordnance Department, presented before a recent meeting of the Canadian section of the Society of the Plastics Industry in Toronto).

Strain-Rosette Analysis Is Effective Design Aid

By Joseph Marin
Pennsylvania State College

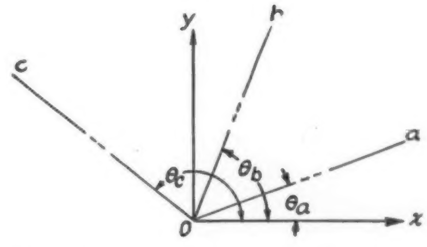


Fig. 1—Three strains with directions measured from the x axis

MATHEMATICAL methods of stress analysis by the theory of elasticity are employed by the machine designer for the solution of many problems. There are some constructions, however, in which the shape of the parts or method of loading makes a mathematical procedure inadequate. Under these circumstances an experimental method of stress analysis must be used. In some problems, also, there is doubt regarding the accuracy of theoretical analysis and an experimental method is used as a check on the theory.

For either purpose there are general experimental methods available as well as special ones for the solution of specific problems. The well-known photoelastic method is a general method that has been used effectively in the determination of stresses for many machine parts. Development of three-dimensional photoelasticity promises even greater aid to the machine designer. Photoelasticity will not be discussed in this series since it has been adequately treated[1].

Another general method, not so well known, for analyzing two-dimensional stresses is the strain-rosette method. The object of this article is to show how this method can be used by the machine designer for analyzing stresses. In this discussion emphasis is placed on the fundamentals of the procedure rather than the experimental techniques. A brief introduction to deformation methods in general will be given first.

Often stresses are determined by measuring the strain on built-up models of machines or structures. This procedure may be used for simple stresses in which case the strain is measured in the known direction of the stress. The model is an elastic material and the loads are maintained below the region of yielding. Then, assuming Hooke's Law, the simple stress is obtained directly by multiplying the unit strain at the point by the modulus of elasticity of the material. This method is utilized for members subjected to simple axial stresses and to bending stresses. It has been employed widely on a variety of structural models and in the analysis of machine parts.

Other stress functions than axial strains sometimes are measured to determine stresses. In tests on built-up structures it is a common procedure to determine the deflections at panel points. Stresses in railroad track have been investigated by measuring both deflections and strains[2]. Strain gages have also been useful in the analysis of stresses at connections of structural members such as riveted joints[3]. There have been too many reports to mention here of analysis of stresses by measuring deformations. The bulletins of the engineering experiment stations in several institutions cover many of the investigations made.

Though measurement of strain or deflection is useful in the case of simple stresses, the procedure for determining the stresses is not so simple when a combined state of

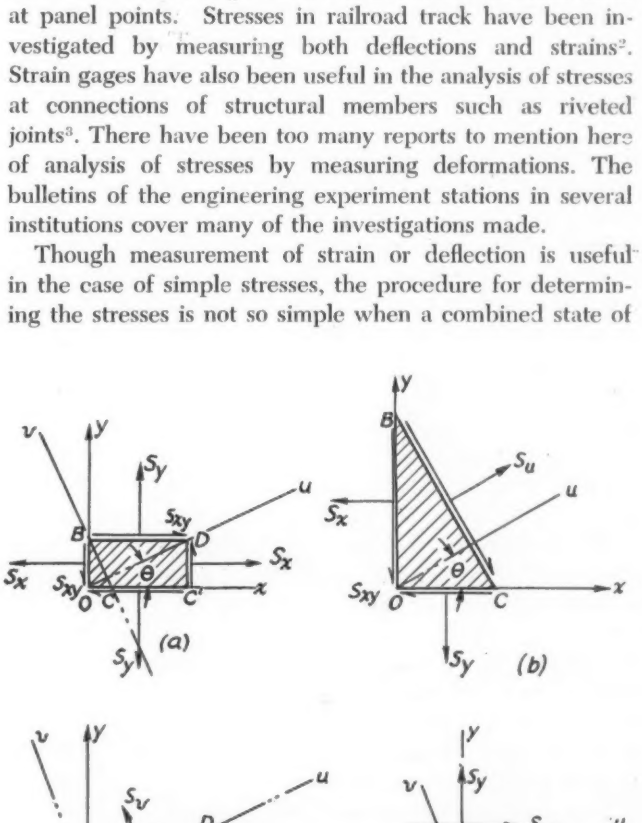


Fig. 2—Stress components referred to x and y directions (a), u axis (b), u and v axes at (c) and principa lstrains (d)

[1]"Photoelastic Analysis in Commercial Practice"—R. E. Orton, MACHINE DESIGN, 1940; "A Review of the Photoelastic Method of Stress Analysis"—R. D. Mindlin, *Journal of Applied Physics*, April and May, 1939; and *Photoelasticity*,—M. M. Frocht, John Wiley & Sons, 1941.

[2]For example, S. Timoshenko and B. F. Langer—"Stresses in Railroad Track", *Transactions*, A.S.M.E., Page 277, 1932.

[3]An example of such an application can be found in "Tension Tests of Large Riveted Joints"—R. E. Davis, G. B. Woodruff and H. E. Davis, *Proceedings* A.S.C.E., May, 1939, Page 805.

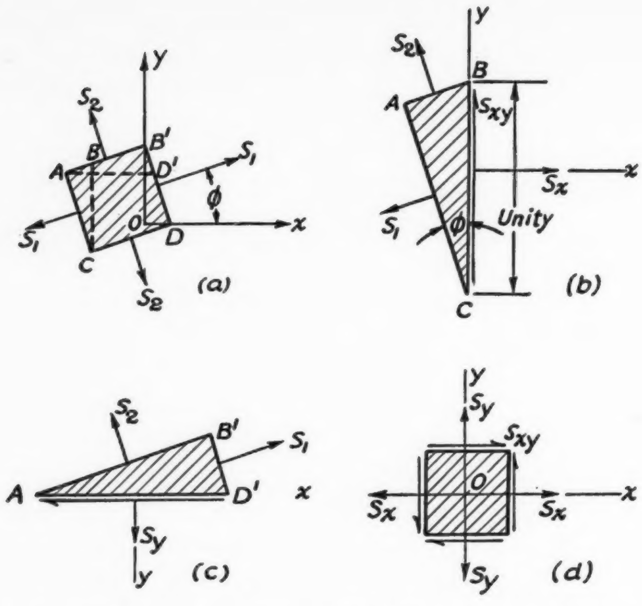


Fig. 3—Principal-stress method for determining stress components

stress occurs. The remainder of this discussion will be devoted to such cases.

If the principal stresses and the orientation of the axes of the principal stresses are known, the state of stress at a point on the surface of a stressed material is completely known. That is, in a two-dimensional stress system, the stress is completely specified by three quantities. In any experimental method to define a two-dimensional stress system it therefore will be necessary to specify three independent quantities or stress functions for the point considered. In the strain-rosette method the stress at a point is completely determined by measuring the unit strains at the point in three independent directions. A strain in a fourth direction is sometimes measured to obtain a more accurate value of the stress or for purposes of checking the results. The state of stress at a point will be obtained in terms of the principal stresses and their directions.

The problem can be stated more clearly by referring to *Fig.* 1 which represents the three measured strains ϵ_a, ϵ_b and ϵ_c acting in the directions *a*, *b* and *c*, defined by the angles θ_a, θ_b, θ_c. In the diagram *x* and *y* represent two arbitrary rectangular axes. Given these three strains and their directions, the problem is to determine an expression for the principal stresses and their directions.

Stress components referred to the *x* and *y* directions at point *O* in *Fig.* 1 are shown in *Fig.* 2*a*. Considering a plane in this element defined by *BC*, as shown in *Fig.* 2*b*, so that the normal stress S_u acting at right angles to this plane is at an angle θ to the *x* axis, for equilibrium of forces in the *u* direction,

$$S_u = S_x \cos^2\theta + S_y \sin^2\theta + S_{xy} \sin\theta \cos\theta \quad \ldots (a)$$

Fig. 2c represents the portion *ODC'* of the rectangular element *OBDC* such that the *v* axis is normal to the *u* axis. Then for equilibrium of the stresses in the *v* direction the normal stress S_v is

$$S_v = S_x \sin^2\theta + S_y \cos^2\theta - S_{xy} \sin\theta \cos\theta \quad \ldots (b)$$

The unit strains in the *u* and *v* directions are by Hooke's Law,

$$\epsilon_u = \frac{1}{E}(S_u - mS_v) \quad \ldots (c)$$

$$\epsilon_v = \frac{1}{E}(S_v - mS_u) \quad \ldots (d)$$

where m = Poisson's Ratio.

Placing the values of the normal stresses S_u and S_v from Equations *a* and *b* in Equations *c* and *d*, the strains in the *u* and *v* directions are shown in the following Equations *e* and *f*.

Measured Strains	ϵ_a	ϵ_b	ϵ_c			
	...	...	...			
Direction of Strains	...	...	...	θ_a	θ_b	θ_c
	...	...	...	...	...	...
	sin θ			...	...	...
	*sin*² θ			...	...	...
	cos θ			...	...	...
	*cos*² θ			...	...	...
Equations for Strain Components $\epsilon_x, \epsilon_y, \gamma_{xy}$ (**Equation 1**)	$\epsilon' = \epsilon_x \cos^2\theta' + \epsilon_y \sin^2\theta' + \gamma_{xy} \sin\theta' \cos\theta'$					
	$\epsilon_a =$ .... (*a*)					
	$\epsilon_b =$ .... (*b*)					
	$\epsilon =$ .... (*c*)					
Values of strains $\epsilon_x, \epsilon_y, \gamma_{xy}$ (**solving Equations a, b and c**)	ϵ_x		ϵ_y		γ_{xy}	
	...		...		...	
Principal Strains	ϵ_1	$= \frac{\epsilon_x+\epsilon_y}{2} + \frac{1}{2}\sqrt{(\epsilon_x-\epsilon_y)^2+\gamma_{xy}^2}$	= ...			
	ϵ_2	$= \frac{\epsilon_x+\epsilon_y}{2} - \frac{1}{2}\sqrt{(\epsilon_x-\epsilon_y)^2+\gamma_{xy}^2}$	= ...			
Direction of Principal Strains	*tan* 2ϕ	$= \gamma_{xy}/(\epsilon_x-\epsilon_y)$	= ...			
Principal Stresses	S_1	$= \left(\frac{E}{1-m^2}\right)(\epsilon_1 + m\epsilon_2)$	= ...			
	S_2	$= \left(\frac{E}{1-m^2}\right)(\epsilon_2 + m\epsilon_1)$	= ...			

$$\epsilon_u=\frac{1}{E}\Big[S_x(\cos^2\theta-m\sin^2\theta)+S_y(\sin^2\theta-m\cos^2\theta)+$$

$$(1+m)S_{xy}\frac{\sin^2\theta}{2}\Big] \qquad \text{(e)}$$

$$\epsilon_v=\frac{1}{E}\Big[S_x(\sin^2\theta-m\cos^2\theta)+S_y(\cos^2\theta-m\sin^2\theta)-$$

$$\frac{1+m}{2}S_{xy}\sin^2\theta\Big] \qquad \text{(f)}$$

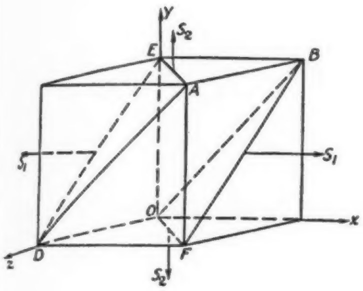
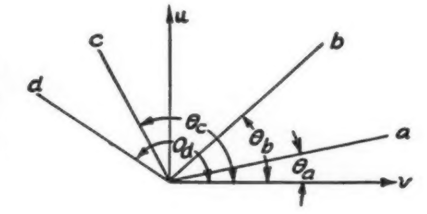


Fig. 4—Representation of planes on which stresses act

Fig. 5 — Principal stresses in terms of four strains measured from point O



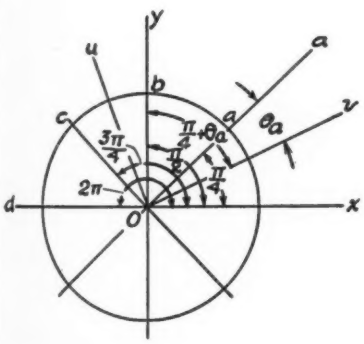


Fig. 6—Interpretation of stresses acting on lines at forty-five degrees

Values of the stress components in terms of the strain components referred to the x and y axes are, by Hooke's Law,

$$S_y=\left(\frac{E}{1-m^2}\right)(\epsilon_y+m\epsilon_x) \qquad \text{(g)}$$

$$S_x=\left(\frac{E}{1-m^2}\right)(\epsilon_x+m\epsilon_y) \qquad \text{(h)}$$

$$S_{xy}=G\gamma_{xy}=\frac{E}{2(1+m)}\gamma_{xy} \qquad \text{(i)}$$

where E = modulus of elasticity in tension and G = modulus of elasticity in shear.

Placing the values of these stress components in Equations e and f, the expressions for the strains referred to the u and v axes are

$$\epsilon_u=\epsilon_x\cos^2\theta+\epsilon_y\sin^2\theta+\gamma_{xy}\sin\theta\cos\theta \qquad \text{(j)}$$

$$\epsilon_v=\epsilon_x\sin^2\theta+\epsilon_y\cos^2\theta-\gamma_{xy}\sin\theta\cos\theta \qquad \text{(k)}$$

These equations give the values of the strains in the two perpendicular directions inclined at an angle θ with two other axes x and y. These strains are also given in terms of the strains in the x and y directions. Equation j can be used for obtaining the strains in the directions a, b and c of *Fig.* 1 provided θ_a, θ_b and θ_c are substituted respectively for θ in Equation j. The strains in those three directions are, therefore,

$$\left.\begin{aligned}\epsilon_a&=\epsilon_x\cos^2\theta_a+\epsilon_y\sin^2\theta_a+\gamma_{xy}\sin\theta_a\cos\theta_a\\ \epsilon_b&=\epsilon_x\cos^2\theta_b+\epsilon_y\sin^2\theta_b+\gamma_{xy}\sin\theta_b\cos\theta_b\\ \epsilon_c&=\epsilon_x\cos^2\theta_c+\epsilon_y\sin^2\theta_c+\gamma_{xy}\sin\theta_c\cos\theta_c\end{aligned}\right\} \qquad (1)$$

Since the three strains ϵ_a, ϵ_b and ϵ_c and their directions are known, it is possible by Equations 1 to determine the values of the strain components ϵ_x, ϵ_y and γ_{xy}. Referring to Equation j and considering the angle θ to vary, there will be one direction of θ for which the strain ϵ_u is a maximum and another for which it is a minimum. These strains are called the principal strains. For a maximum or minimum value of ϵ_u in Equation j,

$$\frac{d\epsilon_u}{d\theta}=0 \text{ or } \tan 2\phi=\left(\frac{\gamma_{xy}}{\epsilon_x-\epsilon_y}\right) \qquad (2)$$

where ϕ is the value of θ for maximum or minimum ϵ_u. Placing this value of the angle back in Equation j, the principal strains are

$$\left.\begin{aligned}\epsilon_1&=\frac{\epsilon_x+\epsilon_y}{2}+\frac{1}{2}\sqrt{(\epsilon_x-\epsilon_y)^2+\gamma_{xy}^2}\\ \epsilon_2&=\frac{\epsilon_x+\epsilon_y}{2}-\frac{1}{2}\sqrt{(\epsilon_x-\epsilon_y)^2+\gamma_{xy}^2}\end{aligned}\right\} \qquad (3)$$

Since the strain components ϵ_x, ϵ_y and γ_{xy} are known from Equations 1, the principal strains are completely defined in magnitude by Equations 3 and in direction by Equation 2.

Principal stresses, determined by Hooke's Law, in terms of the principal strains are

$$\left.\begin{aligned}S_1&=\left(\frac{E}{1-m^2}\right)(\epsilon_1+m\epsilon_2)\\ S_2&=\left(\frac{E}{1-m^2}\right)(\epsilon_2+m\epsilon_1)\end{aligned}\right\} \qquad (4)$$

The principal stress values thus can be obtained from Equations 4 and their directions by Equations 2. For convenience in calculating these stresses and their directions

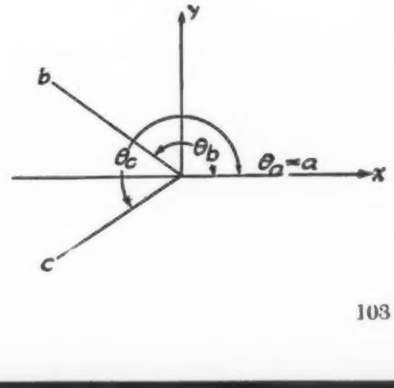


Fig. 7—Equiangular strain-rosette arranged so that θ_a is zero

a tabulation of the results, as shown in the accompanying table (Page 102) is useful[4].

It is sometimes desired to obtain the stress components S_x, S_y and S_{xy} with respect to the x and y axes. This can be done by substituting the values of the strain components ϵ_x, ϵ_y and γ_{xy} determined from Equations 1 in Equations g, h and i. This gives completely the values of the stress components.

Another procedure for determining these components is to use the values of the principal stresses and their directions. These are shown in *Fig. 3a*. To determine the stress components shown in *Fig. 3d* referred to the x and y axes, a free body diagram ABC shown in *Fig. 3b* is considered. For equilibrium of stresses in the x direction,

$$S_x = S_2 \sin^2\phi + S_1 \cos^2\phi \qquad (5a)$$

For equilibrium of stresses in the y direction the shear stress component must be

$$S_{xy} = \left(\frac{S_1 - S_2}{2}\right) \sin 2\phi \qquad (5b)$$

If the free body diagram $AB'D'$ of the element $AB'DC$ is considered as shown in *Fig. 3c*, then for equilibrium of stresses in the y direction,

$$S_y = S_1 \sin^2\phi + S_2 \cos^2\phi \qquad (5c)$$

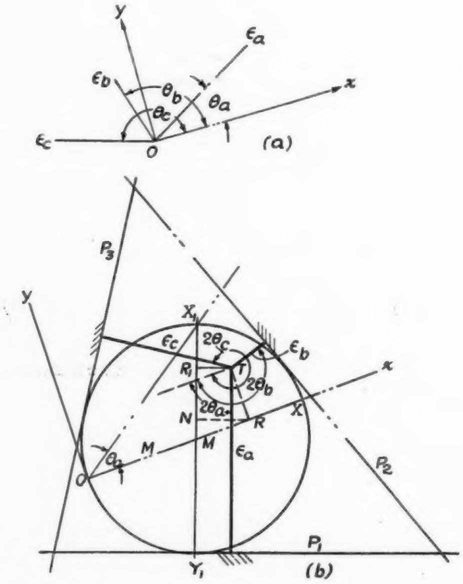


Fig. 8—Land's circle method for determining stresses

The above equations give the three stress components referred to the two sets of axes x and y. These values are given in terms of the principal stresses and their directions.

Maximum shearing stress at a point in a stressed member often must be determined. This stress is easily obtained from equation 5b since by inspection the maximum value of the shear stress, as ϕ varies is for a value of $\phi =$ 45 degrees. That is,

$$(S_{xy})_{max} = (S_{xy})_{\phi=45°} = \frac{S_1 - S_2}{2} \qquad (6a)$$

It may be concluded from Equation 6a that the maximum value of the shearing stress is half the difference of the principal stresses. This stress acts on a plane $ABOD$, Fig. 4. It is important to note, however, that the value of the maximum shear stresses acting in planes $EAFO$ or $EBFD$ may be greater than that acting in plane $ABOD$ as given by Equation 6a. This maximum shear stresses for planes $EAFO$ and $EBFD$ are

$$(S_{xy})_{max} = \frac{S_1}{2} \qquad (6b)$$

and

$$(S_{xy})_{max} = \frac{S_2}{2} \qquad (6c)$$

Absolute maximum value of the shear stress will be given by one of Equations 6. Equation 6a apparently will govern

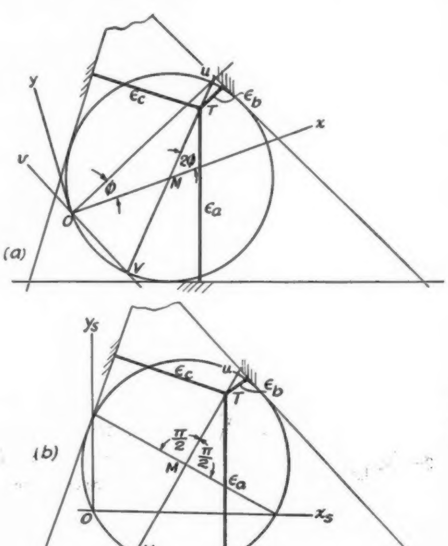


Fig. 9—Graphical construction for determining principal strains and maximum shearing strain

when the two principal stresses are of opposite sign. On the other hand, either Equation 5b or 6c will govern when the principal stresses are of the same sign. Depending upon which principal stress is a maximum, one or the other of these equations determines the maximum shear.

MEASUREMENT OF STRAINS IN FOUR DIRECTIONS: There have been several modifications of the above procedure for determining the stresses at a point. One method consists of measuring the strains in four directions and using the method of least squares to determine the best average value of the principal stresses[5]. That is, this procedure attempts to minimize effects of errors in measurements.

It is desirable in using this procedure to obtain the principal stresses in terms of the four strains ϵ_a, ϵ_b, ϵ_c and ϵ_d measured in the four directions at point O, as shown in *Fig. 5*. If u and v are the principal stress directions and the gage lines are designated by the angles θ_a θ_b, θ_c and θ_d, then the values of the strains in these directions, in terms

(Continued on Page 162)

[4]Also G. E. Beggs and E. K. Timby—"Interpreting Data from Strain-Rosettes", *Engineering News Record*, March 10, 1938.

[5]W. R. Osgood—"Determination of Principal Stresses From Strains on Four Intersecting Gage Lines 45 Degrees Apart," Research Paper RP 851, *Journal* National Bureau of Standards, Vol. 15, Page 579, 1935. Also, L. B. Tuckerman, G. H. Keulegan and H. N. Eaton—"A Fabric Tension Meter For Use On Aircraft". Technical paper National Bureau of Standards BS. 20, 581, 1926, T 320.

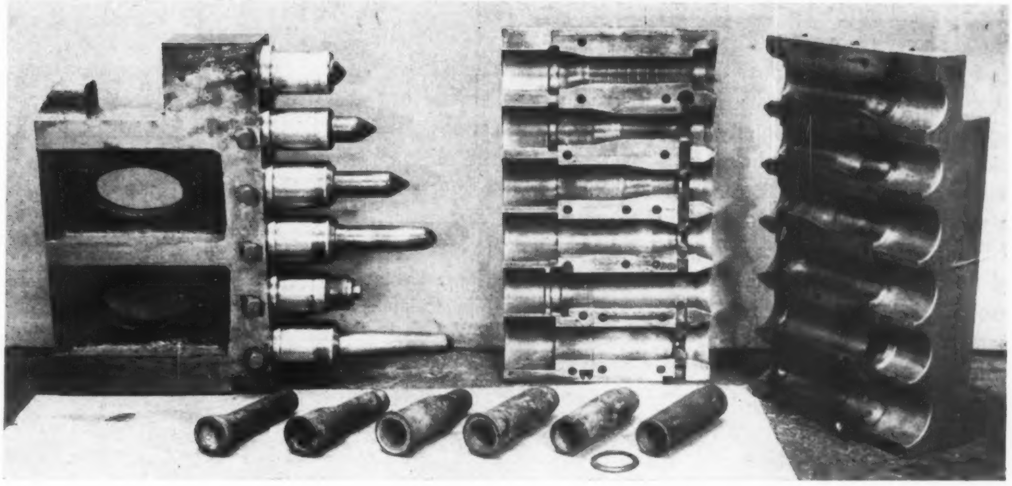


Fig. 1—Dies for 90-millimeter shell forging. Sequence of operations is top to bottom in dies, left to right of parts in foreground

Applying Forgings in Design

Part II—Upset and Press Forgings

By Colin Carmichael

PART of the improvement in physical properties of metals as a result of forging is directional in nature, due to the extension of metal grains in the direction of rolling prior to forging. The designer must therefore consider the manner in which the piece will be forged in order to take advantage of the improved physicals, particularly in the case of parts subject to impact and fatigue loading. Because the resistance to impact is greater along than across the fibers, tensile loads should be parallel to the grain and shearing loads perpendicular.

An excellent example of how the fibrous structure is modified in a forging is shown in *Fig.* 2, which is a gear blank cross-sectioned and etched to show the flow lines. Lines which were originally parallel in the bar stock have been upset in a forging machine and flow radially in the upset portion. It is evident that the fibers have the most favorable orientation for dealing with the loads on the gear teeth which would subsequently be cut in the rim. Such a part if turned from a solid bar would have the fibers parallel to the axis and therefore most unfavorably oriented. Difference in strength in partly due to the greater interference with the movement of slip planes across than along the grains.

Designing Upset Forgings

Upset forgings, produced in a machine with a horizontal action, are commonly made from round bar stock which is heated to forging temperature as it is fed to the machine. Forging dies consist of a reciprocating plunger driven by a crank or eccentric, and a pair of gripping dies, *Fig.* 1. One die is fixed while the other can be moved away from its mate to allow the finished part to be ejected and the new length of stock inserted. Parting line between the two dies is in the plane of motion of the plunger, while the motion of the plunger and the opening and closing of the dies are synchronized. Since the dies open and close during the forming of the part, the de-

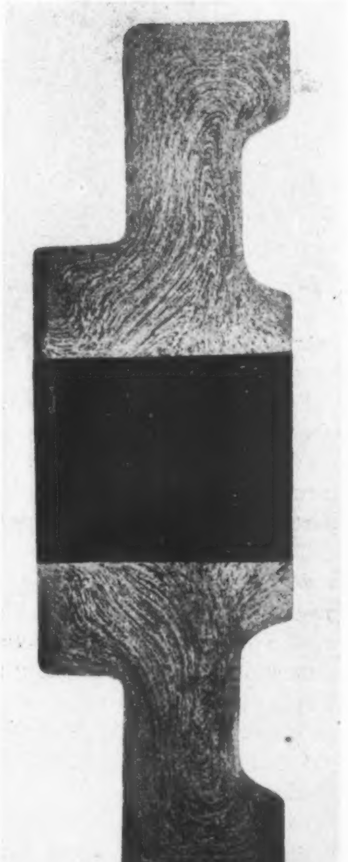


Fig. 2—Upset gear blank sectioned and etched shows flow lines favorably oriented for taking the applied load

signer of the forging should remember that the movable gripping die must be free to move away from the stationary die after the part is formed. Undercuts and projections that would interfere must therefore be avoided.

Unsupported length of stock that can be gathered or upset in one blow is usually not more than three times the diameter of the bar, otherwise buckling or column action will occur. However, if the diameter of the upset portion is not more than one and one-half times the bar diameter, this length may be exceeded, provided also that the amount of unsupported stock beyond the face of the die does not exceed the bar diameter. The practical effect of these general rules is to control the number of operations that will have to be performed to complete the piece, thus affecting the total cost of the forging operation.

Recent improvements in the design of forging machines, especially in the provision of ample rigidity and accurate alignment, have made possible the production of forgings much closer to finished dimensions than heretofore was practical. Most forgings require only 1/16-inch on a side for finishing, others such as valves for airplane engines being held to such close limits that they may be finished by grinding only.

Fig. 3—Above—These parts were all produced on upset forging machines

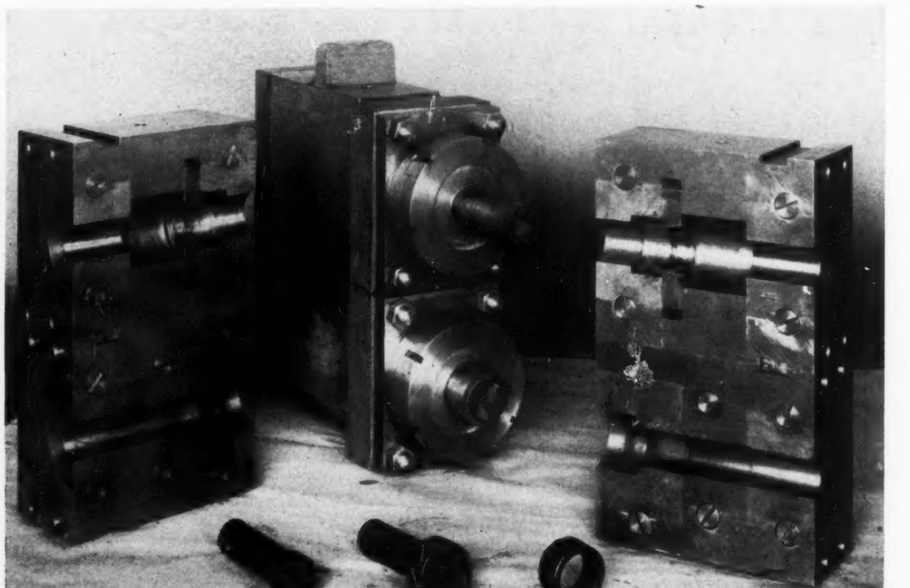


Fig. 4—Left—Piece shown in center foreground is formed in lower step of the die. Ring is punched out in upper step, leaving wad on end of bar which enters into next upset

Because forging machine dies open up to free the completed forging, it is seldom necessary to provide draft except for jobs such as cluster gears where deep narrow impressions must be provided in the dies. Holes in the forged parts are punched on the forging machine itself.

The set of dies illustrated in *Fig.* 1 is used in producing a 90-millimeter shell forging. A series of impressions is used, the shape of the piece after each stage being shown in the foreground. This forging is held to such close dimensions that no machining is required in the bore and only a small amount on the outside. Shell is bell-mouthed to distribute the metal properly for subsequent nosing.

Other examples of forgings produced on the forging machine are shown in *Fig.* 3, illustrating not only the diversified type of work that can be handled but also the closeness to which modern machine forgings can be held to final size. The dies for producing a forged ring from bar stock are shown in *Fig.* 4. An excellent example of an upset forging in aluminum is the rayon spinning bucket, *Fig.* 5.

Press forgings, produced on a vertical press using two solid dies (*Fig.* 6), combine some of the characteristics of drop and upset forgings. By providing mechanically operated knockouts which eject the forging from the die impression as soon as the dies start to reopen, press forgings may be designed without draft while die life is increased because of the limited time of contact between dies and hot metal.

Forging Improves Strength and Accuracy

Typical hot-pressed parts in brass alloys are shown in Fig. 7. Such parts are much stronger than sand castings of the same material, due to the forged structure and grain refinement. Inasmuch as internal cavities in most brasses and bronzes will not weld when forged, as does steel, forging cannot be relied upon to close up such cavities and the original ingot or stock must be sound to begin with. Improvement in density due to compacting, with resulting increase in strength is greatest with the brasses or high zinc bronzes. Forgings produced on modern machines often are held to such close tolerances that a subsequent cold or semi-hot coining operation is sufficient to finish the part accurately to size.

Supplementing other forging processes, forging rolls afford a rapid and economical method of producing certain

shapes. A typical example of the work such rolls are performing in the war program is shown in *Fig.* 8. A propeller blade blank, shown at the man's back, is drawn through rolls which are formed for only a portion of their circumference. After passing through the rolls the blade has a tapered elliptical section of proper proportions to fill the hammer dies which complete the forming. Uninterrupted fiber is thus retained from base to tip of the blade.

Cold forging, also known as cold upsetting or cold heading, is often used for relatively small parts such as nuts, cap screws, etc. Forging action is somewhat similar to that of the hot forging machine but the stock used is cold-drawn wire, sometimes supplied by a wire drawer working in conjunction with the cold-heading machine.

Distinction Between Hot and Cold Forging

Dividing line between hot and cold forging is the temperature at which recrystallization occurs in the metal. While hot forging refines the grain the final structure is practically annealed. Cold work, however, hardens the structure and the amount of deformation is limited. Often the reason for cold forging is to take advantage of this hardening, obviating subsequent heat treatment.

Impact extrusion or "squirting" offers interesting possibilities for the fabrication of machine parts which are symmetrical and basically cylindrical in form or of simple shape. In this process a slug or blank lying in a recess which confines it laterally is struck once by a punch of slightly smaller diameter. Metal squirts up through the opening between punch and die, following the form of the punch. Parts so formed are accurate, uniform in structure with excellent mechanical properties, and offer considerable saving in cost.

Commercial forging materials fall naturally into the following groups: Steels, copper-base alloys, light metals, and nickel alloys. For general forging purposes plain carbon steel approximating the composition of SAE 1020 is widely used where heat treating or fine surface finish are unnecessary. For improved strength, wear resistance, dynamic properties, corrosion resistance, response to heat treatment, etc., there is available the whole range of carbon and alloy steels, including the NE steels, information regarding the forging qualities of which should be sought from the forgings producers.

Copper-base alloys include forging brass (60-38 with 2 per cent lead), the most popular for general purposes. Tobin bronze, also popular, has somewhat higher physicals. Manganese bronze and silicon bronze, being harder and tougher, are fairly difficult to forge compared with forging brass. For superior resistance to corrosion silicon bronze, nickel-aluminum bronze and aluminum bronze are highly satisfactory while for good electrical conductivity copper and beryllium copper are used. The softer materials undergo a certain amount of extrusion in the forging

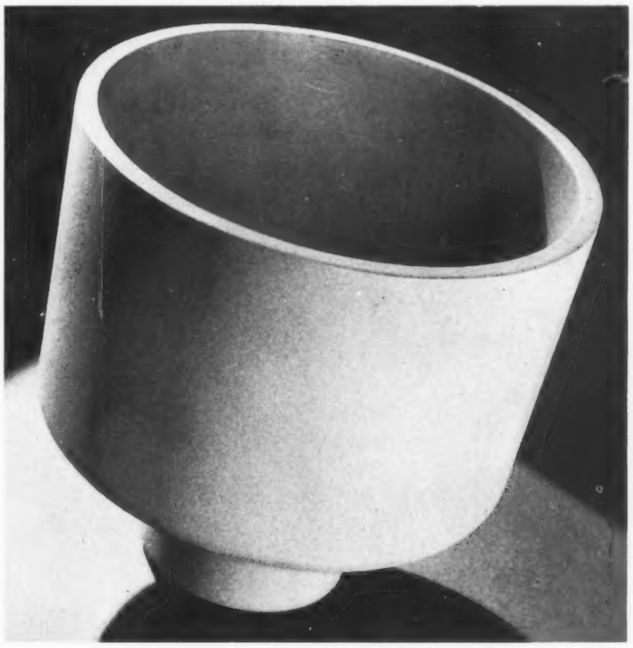
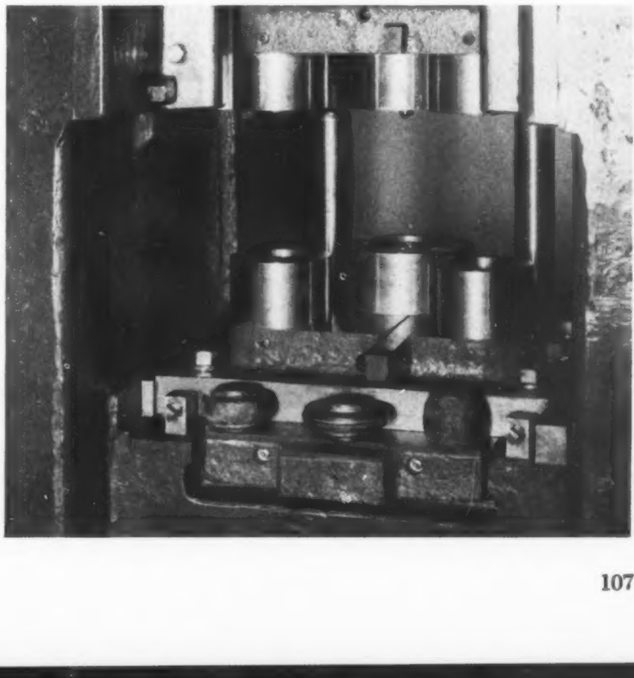


Fig. 5—Aluminum spinning bucket for rayon yarn is rough forged by the upset method

Fig. 6—Below—Shows dies for forging gear blanks in a press, also the three stages in the operation

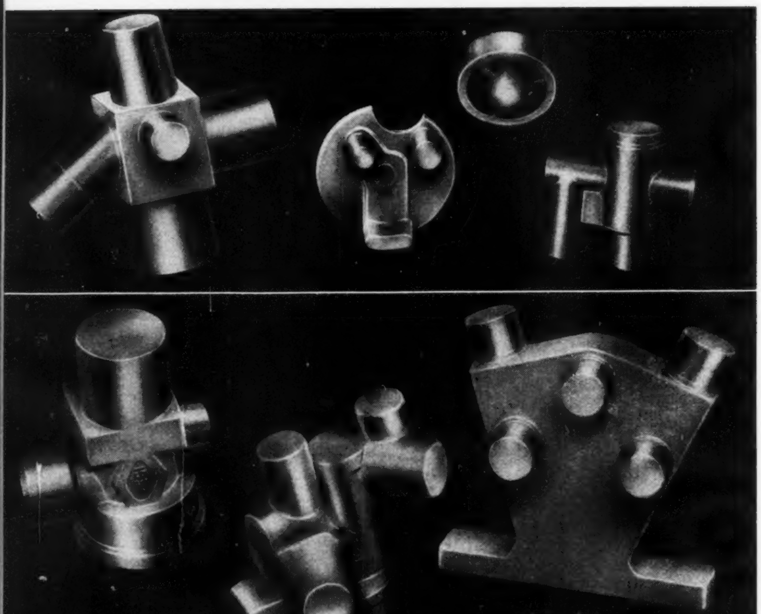


press which aids flow into the die cavities. Larger pieces are often drop forged.

Certain copper-base alloys, notably tin bronzes, beryllium copper and to some extent silicon bronzes are prone to "hot-shortness" or brittleness at forging temperature, causing forging difficulties. Contamination such as is possible with the use of secondary materials greatly increases the hazard. For example, the presence of only .05 per cent silicon or .005 per cent calcium in aluminum bronze may render the material wholly unsuitable for forging, the result being internal rupture, usually along the grain boundaries.

Light metal forgings (aluminum and magnesium alloys) have made spectacular gains in recent months. Forging of aluminum alloys is more difficult than with steel because of the sluggishness with which the metal flows into the dies. Press and hammer forging both are used for such

Fig. 7—Below—Hot-pressed parts such as these can be produced in brass, bronze and other alloys



parts. Because the maximum forging temperature of aluminum is less than 900 degrees Fahr. no visual indication of temperature can be used, thus close temperature control is required. Nonferrous materials in general, and particularly the light metals, require specialized knowledge and experience of successful forging.

Aluminum Offers Range of Properties

Aluminum alloys commonly employed include 25S and 14S, which were primarily developed for forging purposes, and 17S which is popular for aircraft structural parts and fittings because of its superior resistance to corrosion and its machinability. For large and intricate forging jobs such as, for example, crankcases for radial airplane engines, A51S should be specified because of the ease with which it flows. Strength at elevated temperatures is a characteristic of 32S and 18S, while 32S has the additional quality of low coefficient of thermal expansion which recommends it for engine pistons. Other alloys include 53S for certain types of corrosion and 11S for machinability.

Magnesium forging alloys are noteworthy for their high specific strength (strength divided by specific gravity) and are usually press forged. Nickel alloys, including nickel and monel metal, are used primarily for their corrosion resisting properties.

Principles of forging die design are so well established that in a typical forging plant less than one-half of one per cent of the dies have to be redesigned. The skill and knowledge that have made this possible are at the disposal of designers contemplating the use of forged machine parts, and consultation with forgings engineers before a design is too far advanced may be highly profitable.

Machine Design acknowledges with appreciation the cooperation of the following companies in the preparation of this article: The Ajax Manufacturing Co. (*Figs.* 4 and 8); Aluminum Company of America (*Fig.* 5); The American Brass Co. (*Fig.* 7); American Magnesium Corp.; Ampco Metal Inc.; Heppenstall Co.; Kropp Forge Co.; The National Machinery Co. (*Figs.* 1, 2, 3 and 6); The Steel Improvement & Forge Co.; and The Waterbury Farrel Foundry & Machine Co.

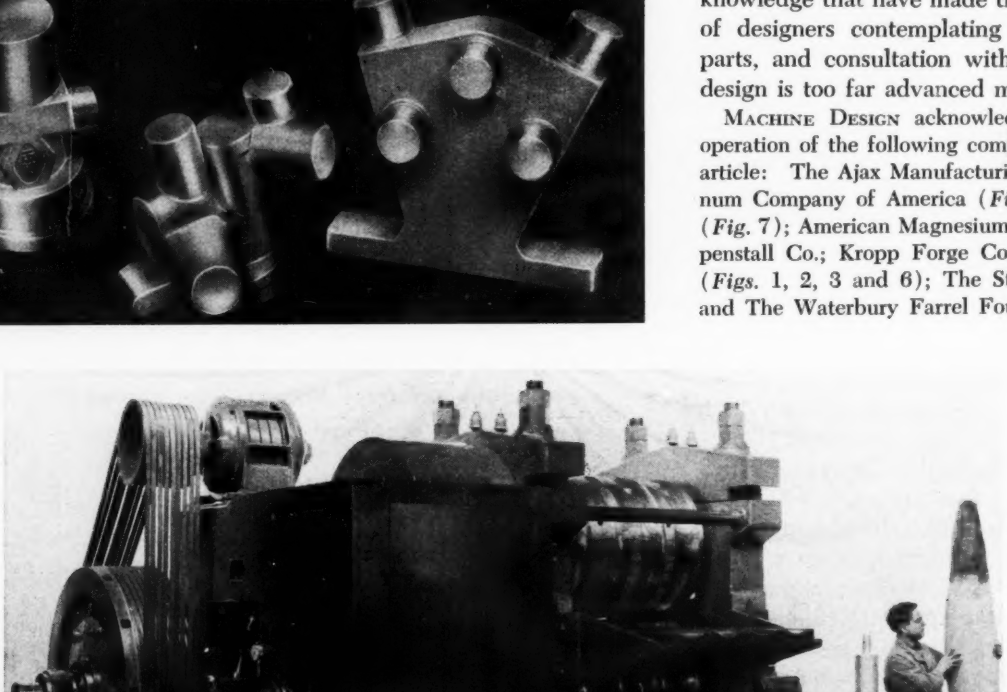


Fig. 8—These forging rolls produce aluminum propeller blade blanks from cylindrical stock

Edge Effect Is Critical in Photoelasticity*

By Walter Leaf
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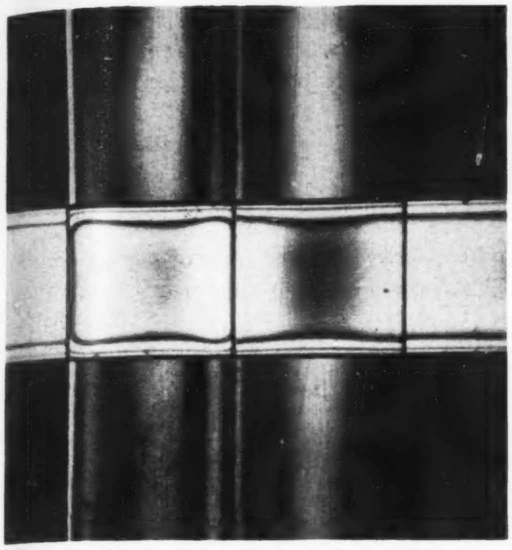


Fig. 1—Photoelastic pattern of two bars with another placed over them at right angles. The two bars are old specimens, one being vacuum dried for three months, both annealed under same conditions. The third bar has considerable edge effect. Composite pattern through dried bar is straight to the edge showing no residual photoelastic effect while the other curls noticeably

Because edge effect is one of the most troublesome sources of error in interpreting photoelastic patterns and because this effect varies greatly depending on the atmosphere, material and age of model, qualitative data for evaluating edge effect is presented in the accompanying article together with suggestions for obtaining accurate results

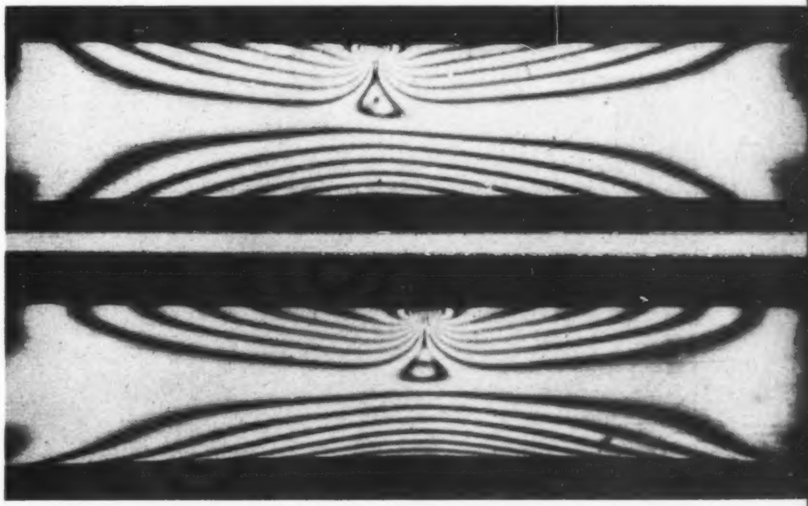


Fig. 2—Photoelastic patterns of the two bars shown in Fig. 1, under bending moments. In the dried bar at the top the lines run straight while in the other they curl at the edges

TIME-EDGE effect in photoelastic models is markedly sensitive to changes in moisture content of the plastic. It is important to recognize this phenomenon in studying fringe patterns. Proper allowances may then be made and techniques developed to minimize errors due this cause.

Illustrating edge effect, two old bars ¾ by ¼ by 6 inches are shown in *Fig.* 1 with another bar in which there is considerable edge effect placed over the two at right angles. One of the old bars was vacuum dried for three months and then annealed with the other. The composite pattern shown is straight to the edge for the dried bar, showing no residual photoelastic edge effect. The other curls noticeably. In *Fig.* 2 the two bars are shown under bending moment. In the dried bar the lines run straight to the edge, while in the other the lines curl.

In a nicely annealed specimen, the edge stress will be compression if moisture is absorbed and tension if moisture is lost. This is true regardless of the grade of plastic under consideration. Whether the freshly cut edges of a model gain or lose moisture depends upon two things only: The present moisture content of the material and the partial water-vapor pressure of the surrounding medium. Thus for any kind of plastic there is an equilibrium reached wherein the percentage of moisture in the outer layer is a function of the moisture content of the surrounding medium. Naturally, the various plastics behave differently in the same medium. In air with 25 per cent relative humidity for example, fresh cut surfaces of BT 61893 Bakelite will absorb moisture while freshly cut surfaces of BT 48005 or Catalin will lose moisture.

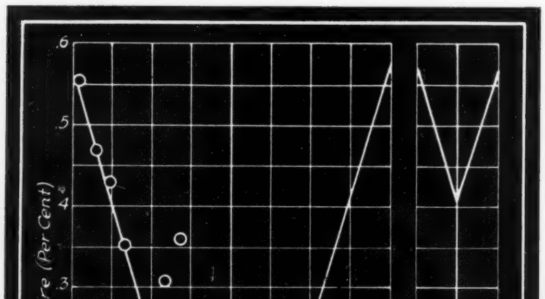
Where a compressive strain has been created by absorption of moisture at the edge over several month's time, creep has taken place and relaxation is not sufficient to remove this creep strain when the moisture is removed. Hence merely removing the moisture from the edge is not effective in removing the time-edge effect. The piece must be annealed. Depth of penetration of moisture into 61893 is seemingly limited to about .2-inch even after three or four years. There is evidently a change of photoelastic constant and Young's modulus with change in

*Based on a paper presented at the recent Eastern Photoelasticity Conference.

moisture content of the material.

Data on absorption and loss of moisture in air and in water for the three plastics previously mentioned are shown in *Fig.* 4 which have been recorded on a calendar basis to show the changes of the various pieces under the same changing conditions. Most of the work was done during the summer and fall of 1942 in Denver when the weather was abnormally dry so that the numerical data would not necessarily be applicable to wetter climates. Trends, however, are definitely indicated.

No standard-shaped specimen has been used in this investigation for three reasons: First, accurate numerical data is of no particular importance, trends being sought. Second, in some of the work, old surfaces were necessary, so any suitable piece available was used. Since absorption is a function of surface layers of not very great depth, pieces were chosen where possible so that the interference at corners and from an opposite surface would be at a minimum. Third, until quantitative data has been collected, there is no background for the choice of a properly shaped quantitative specimen.



The curve labeled "BT 61893, New Surfaces, in Air" gives increase in weight for a piece of this material .2 by .6 by 2.4-inch in size. Cut from the interior of a 1-inch block, from the start of the experiment until the end of October, a compressive edge effect, looking through the .2-inch thickness, built up to a value of a little over one and one-quarter bands. A compensator bar with uniform bending moment was used to determine the stress condition. The shape of the blacked-out area of the composite pattern is the shape of the stress diagram across the section studied, and the fringe order in the compensator bar gives the scale.

On November 16 the edge stress had fallen off about one-quarter band from the value a few hundredths-inch inside, so that the stress diagram was then a distorted *W* rather than a *U* as previously. The specimen showed a loss of only .0009-gram from a total of 7.5499 grams or only 12 parts in a hundred thousand, yet this extremely slight change in weight gave an easily detectable change in stress pattern.

The specimen of Catalin was cut from a piece ⅜-inch thick and at least 18 months old. This specimen was ⅜ by ½ by 1 inch, having only four new surfaces out of the six, yet continued to lose moisture at the rate indicated a total of .027-gram from 3.5307 or .76 per cent. The edge stress was tension of about seven bands on November 18 looking through the ⅜-inch thickness. A piece of 48005 was cut from the interior of a thick block and was investigated for loss of weight in air. The stock was at least four years old. This material is unique in that it has the lowest absorption rate in water and by far the greatest rate of loss in air. Small pieces of each material were immersed in water and the change in weight noted as shown.

A piece of Catalin ⅜ by ¾ by 4¾-inch, weighing 29.5025 grams was held at 125 degrees Cent. for 5 days in air in the annealing oven. It lost 1.9562 grams weight, or 6.6 per cent. It turned a deep red, and had four bands of tension at the edge. Several cracks from the high internal stress were formed.

The data so far reported explains why it is impossible to anneal Catalin and 48005 by the usual methods, since the edge stress is tensile caused by loss of moisture, and heating accelerates this loss. It is obviously possible to anneal either of these materials if the moisture content of the surrounding medium be kept

Fig. 3—Above—Moisture distribution through BT 61893 for both 1/2 and 1/8-inch thick plates. Curves show gradient is constant regardless of thickness and that it is impossible to saturate a plate throughout to the same moisture content

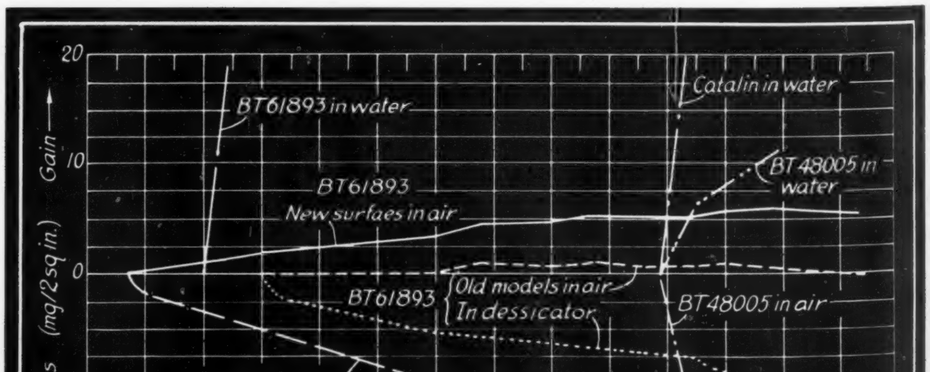


Fig. 4—Right—Absorption and loss of moisture for various plastics recorded on calendar basis

at such a value that there would be no loss or gain of water by the plastic. It is entirely possible that the moisture content in the surrounding medium might have to be varied with changing temperature, making the process very complicated. So far, no attempt has been made to anneal a completely dried piece of either of these materials.

Two other curves are given for old models of 61893. These two models were successive cross sections of a small, three-dimensional rail joint bar model and were ½-inch thick. They weighed around 6.6 grams and had about 3 square inches of surface area. They were four years old in their present shape, and from 1-inch thick stock probably five years old, and had been exposed to the laboratory air. The first of these curves gives the data on the change of weight of one of these pieces, continuing in laboratory air.

Sulphuric Acid Is Best Desiccant

The other curve for the similar model shows its loss of weight while stored in a desiccator. Calcium chloride was used as the desiccant from August 1 to October 14. The desiccator was also loaded with several dozen miscellaneous old models. Freshly annealed models were put into this desiccator from time to time, and developed compressive time-edge effects slowly. International Critical Tables list the vapor pressure of saturated calcium chloride solution as 5.7 millimeters of mercury at 20 degrees Cent. which is above the partial pressure of water in air during dry periods. Consequently, sulphuric acid was put in the desiccator October 14, and immediately the piece lost moisture at a much more rapid rate. As late as January 18, 1943, this piece was still losing weight, although the shape of the curve indicates that equilibrium will soon be reached with a total loss of .0067-gram per square inch.

Vapor pressure of water over 70 per cent sulphuric acid at 20 degrees Cent. is only .723 millimeters of mercury, consequently sulphuric acid is nearly 100 per cent efficient as a desiccant even after becoming diluted. Its disadvantage lies in the fact that one cannot tell what the strength of the acid is in the desiccator. To get around this, a shallow dish say two-third full of fresh acid could be put in the desiccator. When enough moisture to fill the dish had been absorbed, a fresh start could be made.

Two experiments were run to determine the depth of penetration of moisture into 61893. For the first one, an indirect method, an old block .58 by 1 by 3 inches was used. The interior stress condition, looking through the 1-inch thickness, was determined with a compensator as being four bands of tension. The piece was put in a lathe and successive layers faced off parallel to the direction of observation. The same thickness was removed from each side. After each machining, the interior stress condition was determined. The data were:

Thickness	Bands of Tension	Thickness	Bands of Tension
.580	4	.335	1¾
.444	2¾	.307	1½
.415	2½	.280	1¼
.389	2½	.253	1+
.361	2	.209	1+

Graphing these data gives a straight line, with the exception of the fourth observation. The line breaks at thickness .253, being flat from then on, the one band of tension remaining being from creep strain. From these data the depth of penetration of moisture is .580 minus .253 divided by 2, or .163-inch.

In the other method, a similar old bar was faced off in the lathe in increments of 0.25-inch on each side, and the moisture content of about one gram of the shavings determined. The data:

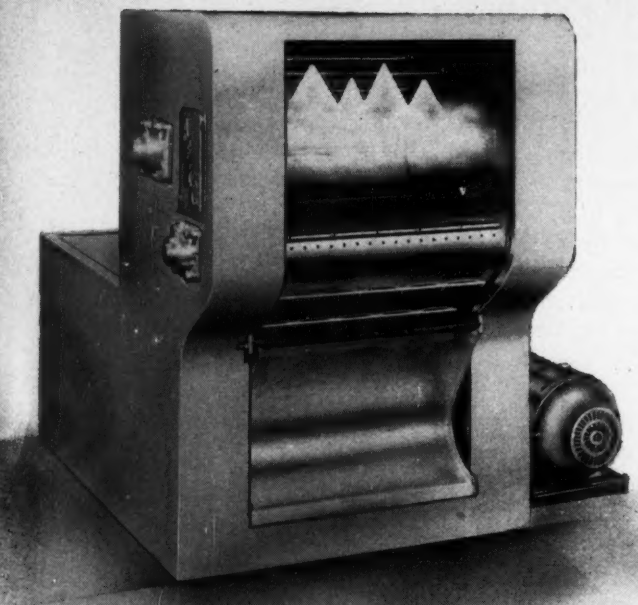
Sample Number	Depth from Surface	Percentage Moisture
1	.013	.554
2	.038	.469
3	.063	.429
4	.088	.350
5	.114	.080
6	.139	.251
7	.164	.360
8	.188	.040
9	.213	.000
10	.236	.000

Graphing these data gives a reasonably good straight line arriving at zero moisture content at the depth of .22-inch. The two methods agree well. Moisture content was determined by desiccation over sulphuric acid at room temperature. The samples were weighed to the nearest one-tenth milligram.

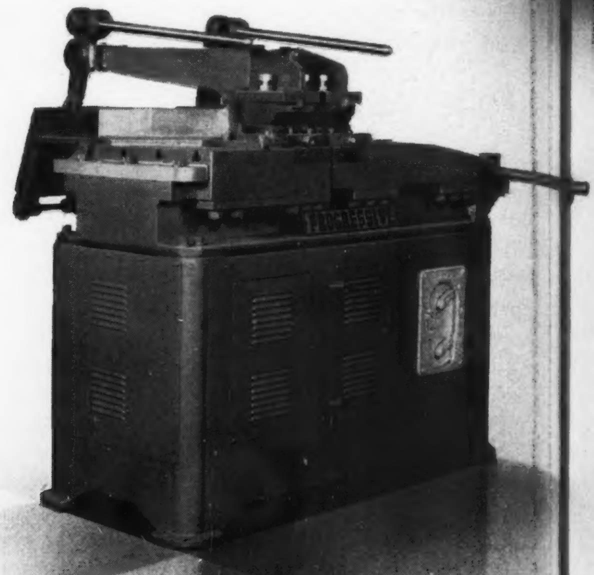
Definite advantages are to be obtained by working with the thinnest possible stock. Seemingly, a curve of moisture content across the thickness of the stock is a "V" with the branches sloping at a fairly definite angle, *Fig.* 3. If thick, a relatively large central portion of the stock is dry. If thin, however, the branches of the curve will meet at the center at a positive moisture content, and further changes on freshly cut edges will be proportionately lower. It is impossible to saturate a plate of 61893 to the same moisture content throughout for there will be no diffusion unless there is a gradient.

Based on these studies, it is recommended that stocks of BT 61893 be kept in storage in open air and that models be stored in an airtight container with 100 per cent sulphuric acid as a drying agent.

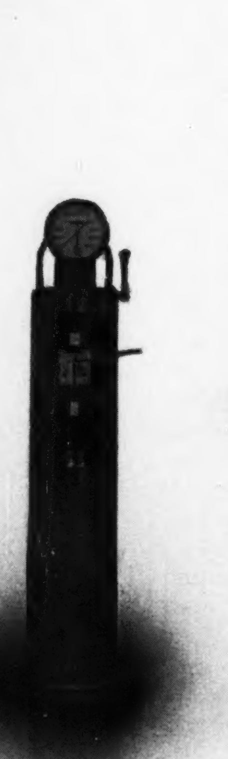
UNDER-SURFACE flaws and defects in heat treatment such as hard or soft spots are readily detected by a simple magnetic test developed at Westinghouse Research Laboratories. Suitable for symmetrical steel parts such as bearing races, the test involves rotating the part at high speed after it has been completely demagnetized to remove all traces of residual magnetism. Then it is highly magnetized so that flux extends outward from the surface being tested. This flux is explored with an electromagnet. Variations in the field, caused by defects, induce a voltage in the coil which are indicated on an oscilloscope. Because the piece is rotated synchronously with the cathode ray sweep, faults which show up as dips can be marked off in degrees and easily located on the test piece. In automatic production testing, the visual indication could be converted to an audible signal or automatic rejection for segregation of faulty pieces.



Left—Continuous apron conveyor in the Tumbl-Spray metal washing machine tumbles the parts while they are subjected to cleansing action of sprays from overhead nozzles. Open-type barrel gives access to parts while in process, facilitating inspection. Reversing the conveyor unloads the machine, discharging the parts over a chute



Right — Equipped with self-aligning lever-operated open face grips having renewable hard file faces, the Baldwin hydraulic spot-weld testing machine accommodates specimens from the smallest gage up to one-quarter inch thickness, no backing plates or liners being necessary. Because the machine is used for production line testing, center of gravity is kept low for ease in hand moving and hoisting hood is provided for crane handling



Below — Spindles of the LeMaire special multispindle machine for drilling bolt circle holes in crankshafts are driven through a cluster box, with connections to gears by universal joints. For drilling and reaming, movement of the spindle head is hydraulically controlled allowing rapid advance, coarse feed, fine feed, and rapid return. For tapping, taps are fed manually, being reversed through the use of limit switches

Above—An electronic device in the Progressive Flash-trol unit anticipates a short circuit in the welding arc, interrupting the feed and jerking back the feed platen a few thousandths of an inch. Upsetting speed and pressure on this flashwelder are obtained through the use of an air-hydraulic booster actuated by a relay which is tripped by the platen when upsetting position is reached

Below—Driven by synchronized
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portable electric sander are
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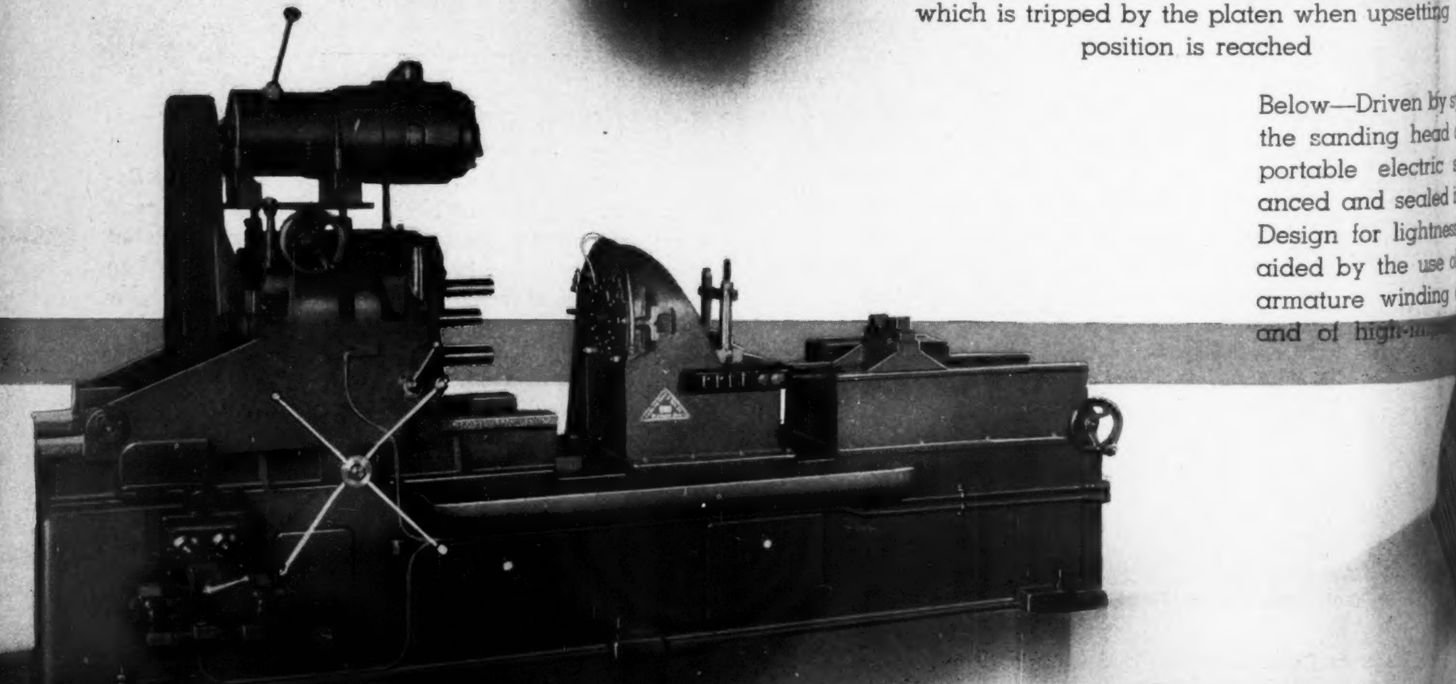
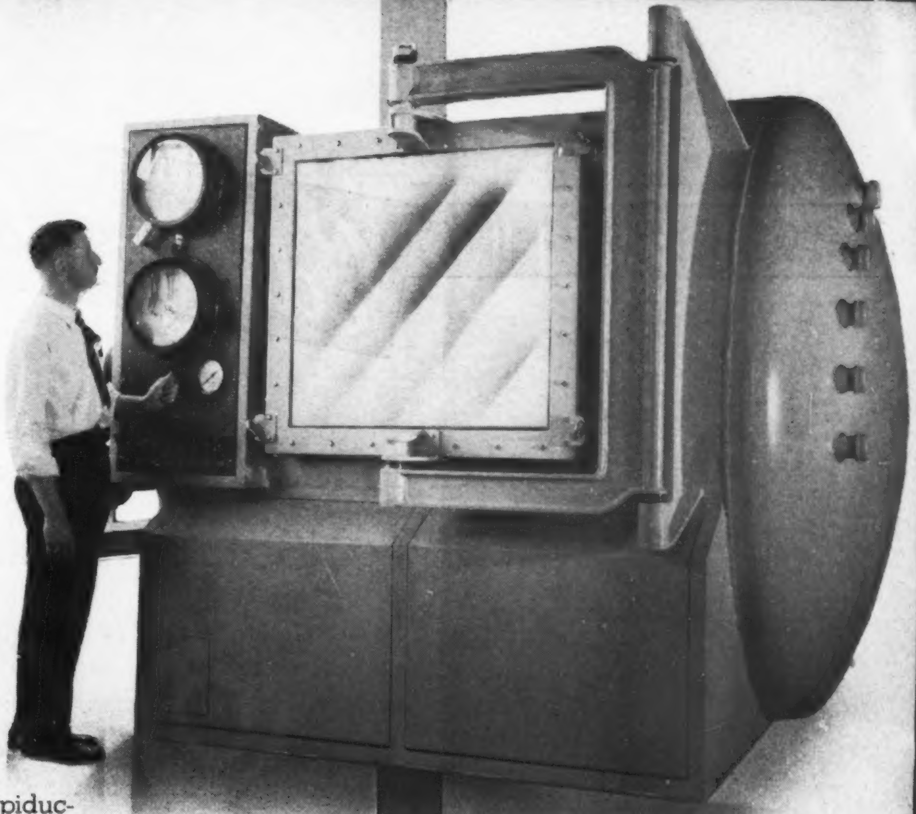
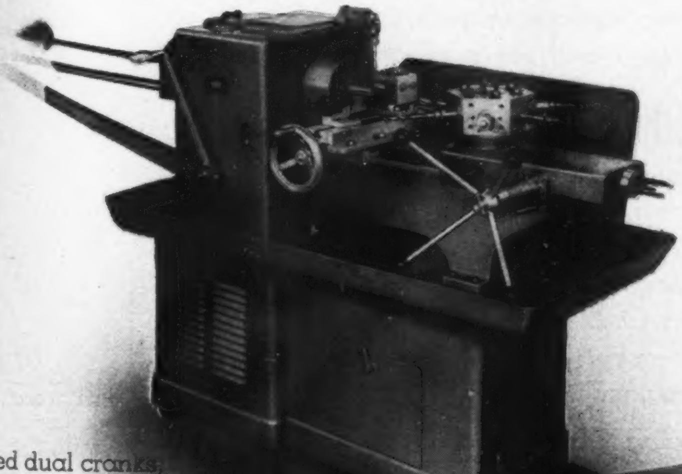


Left—Feed for the Hill-Bartelt thread milling machine is accomplished by a cam synchronized with the work spindle, which governs the complete cycle. Driving elements and electrical controls for this fully motorized machine are completely enclosed, with convenient access doors and plates



Below—Keynote of design of the Oster Rapiduction turret lathe is simplicity, so that unskilled operators may be quickly trained to its use. When equipped with worm drive, machine is used for heavy forming cuts while with direct drive it is adapted to high-speed work. Controls include automatic indexing of the six-station turret

Above—Designed for testing mechanical and radio parts for aircraft used at high altitudes, the Kold-Hold Stratosphere unit operates between temperatures of —75 and 200 degrees Fahr. with pressures as low as three inches of mercury absolute. Equipped with removable silica gel cartridges for fog elimination, the space between panes of the inspection door is sealed against moisture penetration



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d sealed in dustproof gearcase.
r lightness and compactness was
the use of glass insulation in the
winding of the universal motor,
gh- for the handle

Machines Behind the Guns

(For new machine listings, see page 176)

War Production Places Emphasis on Special Machines

IT has been said that within the next few months the peak of production for war (with the exception of aircraft) will have been reached and that from that time on little further increase can be expected.

Assuming there is some truth in this statement, a number of primary reasons might be advanced to account for it. First is the scarcity of materials; second, shortage of manpower; and third, limitations on productive capacity. It is hard to believe, though, that any one of these reasons is valid or that they cannot in turn be overcome.

Engineers in charge of design work can play a relatively small part in connection with shortages of materials, though as much as possible is being accomplished through conservation and substitution. The designer can and will, however, assume increasing importance with regard to the manpower shortage and the productive capacity of machines.

The country's present production, already the greatest in history, has been reached in the main through the use of standard machines which could be obtained and put to work in the least possible time. Only a comparatively small number of special-purpose machines have been produced because of the overwhelming demand for immediate delivery of all types of the more available standard equipment. But as the peak of production with present equipment is more nearly reached the position will rapidly reverse itself.

Special-purpose machines ranging, for instance, from hand tools utilized in aircraft production to huge presses employed in the shipbuilding industry will be just as badly needed as standard equipment has been in the past. And this new special equipment will not only be called on to facilitate the increase of production to even higher levels—it will have to be suitable for operation, in many cases, in the hands of unskilled labor.

That the designer of production equipment (as differentiated from combat machines) is sufficiently versatile to make the switch to reliable, easily operated, special-purpose machines is, we are confident, a foregone conclusion. Special machines were designed and built by the hundreds for automobile mass production before the war. The same design ingenuity and production technique will need to be increasingly applied in winning it.

Chart Aids Selection of Lubricants

By Arthur H. Korn
Chief Engineer
Holly Pneumatic Systems, Inc.

ALTHOUGH choice of machine oils of the proper lubricating qualities becomes ever more important with the use of higher speeds and heavier duty bearings, there seems to exist no general guide for their selection. Lubricants have many properties which are of importance in particular applications. Behavior at high operating temperatures is a basic consideration. Where oil is subject to water contamination it must readily separate from the water. Lubricants which come into contact with certain chemicals should have the necessary resistance to attack. Many available charts give oils of commercial designation which have proved satisfactory for certain engine and machine groups, but no general principle is discernible in such tabulations due to the variety of factors that have to be considered.

TABLE I

Viscosity of Bearing Oils[*]

Service	Abs. viscosity at 122F lb-sec in.$^{-2}$ (Reyns)
Very light duty and high speed	1.4
Light or medium duty and medium or high speed	1.9
Medium duty and medium or high speed	2.9
Medium or heavy duty and medium or high speed	3.8
Heavy duty and slow or medium speed	8.1
Heavy duty and slow speed	11

[*]Based on a table in "The Practice of Lubrication" by T. C. Thomsen (McGraw-Hill Book Co.).

One property of an oil, however, which is a true measure of its lubricating qualities is the viscosity. A significant lead to the selection of oils of proper viscosity appears in TABLE I. The table is indicative of a fundamental law that viscosity should increase directly as the load and be inversely proportional to the speed. Mathematically such a law is written:

$$\mu\frac{n}{p}=\text{constant} \qquad (1)$$

where μ = absolute viscosity of lubricant, pound-second per square inch (Reyn); n = number of revolutions per minute; p = unit pressure on projected bearing area, pounds per square inch.

If this is the law it should be possible to find the constant. It is significant that the term $\mu n/p$ also appears in the equations governing thick film lubrication[1]:

$$2.8\times10^{-6}\left(\frac{\mu n}{cp}\right)^{10/3}\left(\frac{d}{\delta+\Delta+\frac{1}{2}f}\right)^{17/3}\geqq$$

$$\frac{D-d+2(\Delta+\delta)}{d}\geqq .36\sqrt{\frac{\mu n}{cp}}$$

or, neglecting shaft deflection f,

$$\mu\frac{n}{p}\geqq 64c\left(\frac{\delta+\Delta}{d}\right)^2 \qquad (2)$$

where

$$c=1+2\left(\frac{D}{B}\right)^2 \qquad (3)$$

In these equations the notation is:

B = Width of bearing
D = Diameter of bearing (measured)

[1]MACHINE DESIGN, January, 1943, Page 78.

d = Diameter of shaft (measured)
Δ = Roughness of bearing
δ = Roughness of shaft.

To achieve complete separation of the sliding surfaces by a stable oil film, $\mu n/p$ must have the minimum value given by Equation 2, depending on the quality of the surface finishes.

TABLE II

Viscosity and System of Lubrication†

Method of Application	Abs. viscosity at 100F lb-sec in.$^{-2}$ (Reyns)
Circulation	3.0 min.
Splash	4.5 max.
Ring or Chain	5.5 max.
Drop-feed	6.5 min.
Wick-feed	7.5 max.
Hand	8.5 max.

†Compare with the table on Page 348 of "Lubricants and Lubrication" by J. I. Clower (McGraw-Hill Book Co.).

This leads to a genuine criterion which should govern the selection of lubricants. A lubricant should be viscous enough to insure thick film lubrication, yet not unnecessarily viscous because any increase in viscosity means greater power loss through fluid friction and higher bearing temperatures.

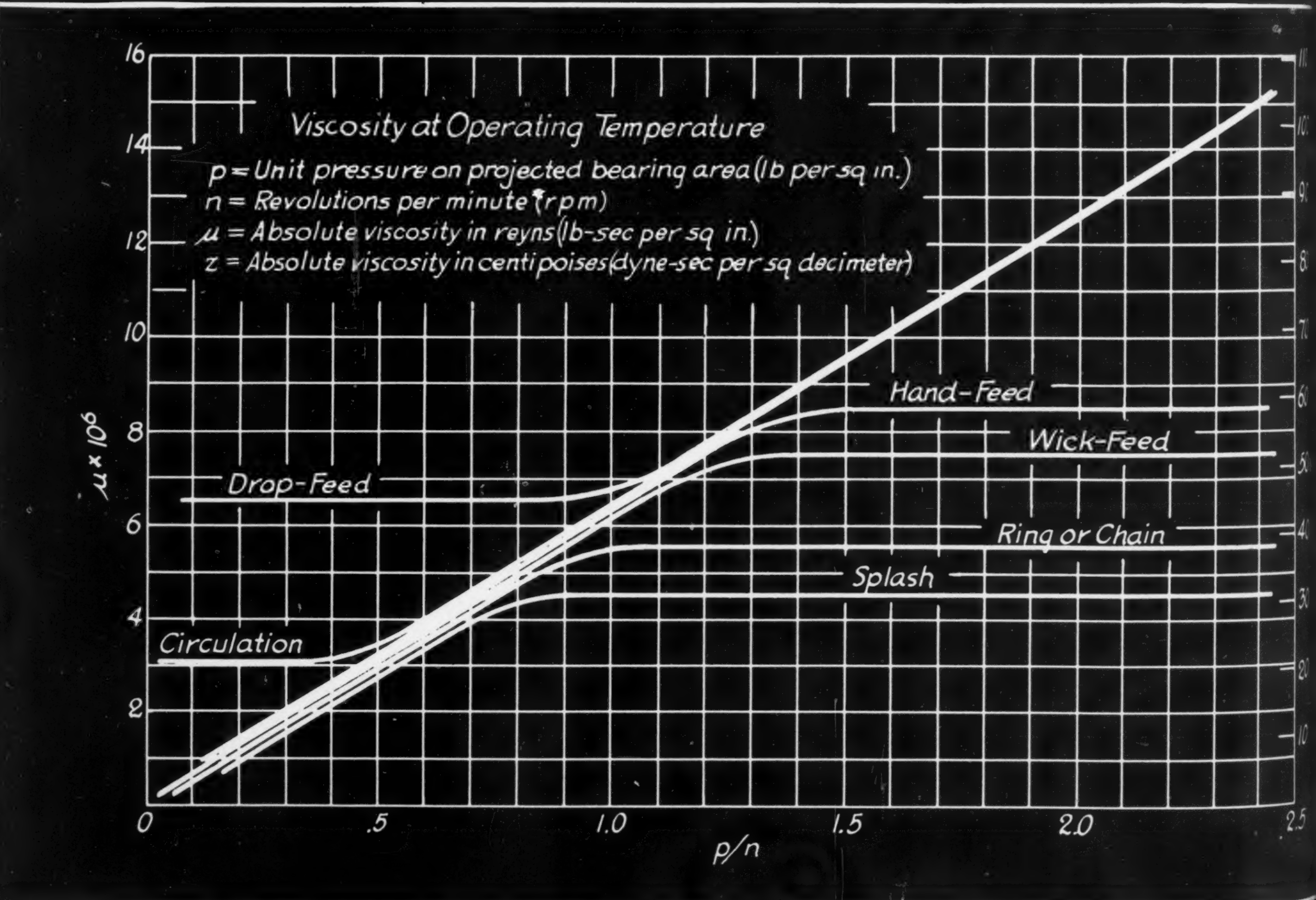
To obtain these conditions even for surfaces of poor finish, a ground shaft having δ = .00015-inch and a reamed bearing having Δ = .0002-inch will be considered. The diameter is assumed to be 2 inches, the surface roughness for smaller sizes being presumed proportional to diameter. The rather unfavorable bearing proportion $D/B = 1$ also is assumed. If these figures are used in Equations 2 and 3 it is found that:

$$\mu \times 10^6 \approx 6\frac{p}{n} \qquad (4)$$

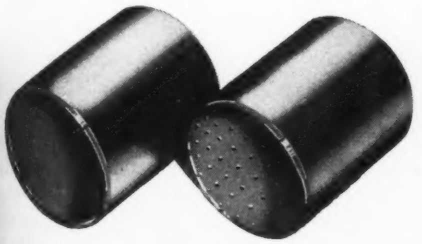
This seems to agree well with viscosity tables given in textbooks, especially for main bearings of reciprocating engines. It also approximates the average of values recommended for a wide variety of other bearing types[2].

Viscosity of a lubricant is not exclusively determined by thick film lubrication. The various systems of supplying oil to the bearings function properly only under certain conditions of maximum and minimum viscosity, TABLE II. Combining Equation 4 and TABLE II, the chart below will serve as a general guide for selecting and specifying lubricants.

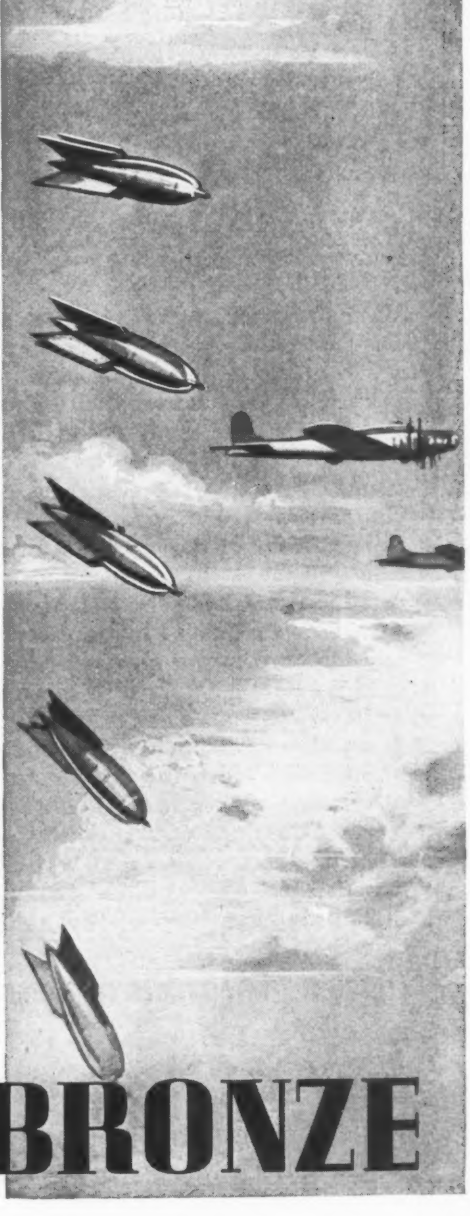
[2]*Fundamentals of Machine Design*, Page 235, 1938, The Macmillan Co.



Speeding Destruction



The business of dropping a package of "eggs" on Tojo is easier and more efficient because of sleeve type bearings. The interesting feature of this application is that it employs a bearing material as new as the war.



Johnson Pre-Cast Bearing BRONZE-ON-STEEL was developed to meet peacetime applications but, like many another product, it was easily converted to armament needs. When peace returns, manufacturers will find that Johnson BRONZE-ON-STEEL . . . combining the bearing qualities of BRONZE with the strength of STEEL . . . will give them greater bearing performance in their product. It will be available as finished bearings or in strip form for stampings. It is an ideal metal for washers or other flat pieces. Complete information can be had by writing the Johnson Bronze Company, 525 South Mill Street, New Castle, Penna.

Sleeve Bearing Headquarters

JOHNSON BRONZE

PROFESSIONAL VIEWPOINTS

". . . is wasting manpower"

To the Editor:

Why should our nation fight this production war with great quantities of obsolete and inefficient machines? We have gone forward on the quickly available expedient of using what we could get soonest, anything to get started.

Our many industrial triumphs were not attained alone by man hours and hard work, nor by sheer motor horsepower. We made special machines that would turn out more work in the space of a one-car garage than an acre of orthodox machines could have done. The half billion people of Europe have had a mathematical superiority over the United States in a coefficient sort of way, and we must have some exponent of our own to make us so successful.

When we seek to explain how we did this we invariably boast of our special machines. We do not dwell upon the volume or the weight of our machinery but upon those examples of mass production wizardry which are outstanding in efficiency.

During the depression the buyer had more than he needed of standard machines and there began a furious development of special machines, designed to do a job efficiently, machines that would sell. Fierce competition was demanding low cost per piece. There was much agitation to tax or restrict such machines and all processes which reduced immediate employment. The rate of this essential development has receded once again, inversely as the volume of manufacture increased and despite an entirely new set of conditions involving new kinds of products, in unprecedented quantities, to be made by increasingly scarcer and unskilled help.

For two years past, war contracts should have intensified an interest in special machines. Everywhere the need is recognized but everywhere the same response. "Why", is asked, "should we invest our money in special machines when we can get Government contracts negotiated on the basis of the equipment we have? A special machine may be unsuited for use on peacetime products."

Men making this statement are not entirely at fault. They are caught in an artificial situation where there is a penalty on the means that normal self interest and competitive intelligence would cause to be developed. No one can plan in an atmosphere clouded with obscurity, mired in regulations and shot through with the lightning shafts of cancellation. The manufacturer can hardly be expected to show zeal for efficiency when the symbol of his market is the sword of Damocles.

Many will admit the mistake in not running a vigorous development program in parallel with the present production plan. It will be said that we no longer have time to design and build elaborate special machines, or that the shops and men are not available. The answer to that is that machine tool and other industries are beginning to divert men now for postwar development; they could design machines which would return the man hours put into them in a period of three or four months and go on and on reducing the critical situation which faces us on manpower.

In many cases the ingredient that makes a special machine


NICKEL
INCO

is ingenuity. The only fault we find with the machines we get off the shelf is that they multiply the operations, men and floorspace, even jigs and tools, inspections and scrap. Opposed to this I have in mind a small machine which has six Delta drillpress heads articulated by a camshaft, with an automatic clamping and conveying mechanism of simple design. It replaces eleven turret lathes and fifteen people, producing work so much more uniform and accurate that uncertainty and scrap are reduced to a point where inspection is almost unnecessary. With eleven operators there were always eleven different kinds of product and 20 per cent scrap. Many more man hours went into the standard lathes than into this special machine.

Haven't we copied old stuff enough times now to begin something better? Shortage of labor can be traced to labor-wasting machines.

—KEITH WATCHER
Cincinnati, Ohio

". . . when designing a bearing"

To the Editor:

The interpretation of the hydrodynamic lubrication theory in the article "Bearing Design as Affected by Lubrication Theory" (MACHINE DESIGN, January, 1943) reading:

> "The equations of hydrodynamic lubrication are characterized by the value $\mu n/cp$. As long as this value remains constant there can be no change in either oil film thickness or heat generation regardless of variations of load p and speed n. . . This is fallacious reasoning which overemphasizes the generation of heat".

is questionable for the following reasons:

1. Oil film thickness is not only a function of $\mu n/cp$, but also of the bearing diameter and the clearance.

2. Assuming a constant coefficient of friction for $\mu n/cp =$ constant (which assumption is only approximate; actually the coefficient of friction is dependent also upon the clearance), then the heat generated is a function of the diameter of the bearing.

Hence, for a constant value of $\mu n/cp$, the oil film thickness and the heat generated are functions of the bearing diameter and the clearance. Clearance in turn is a function of the shaft deflection, surface roughness of bearing and shaft, and of the bearing material used.

When designing a new bearing, the machine designer should check oil film thickness as well as heat generated, which means he must properly coordinate all of the influencing factors; namely, diameter and length of the bearing, unit pressure, revolutions per minute, clearance, surface roughness of bearing and shaft, oil film thickness, temperature, oil viscosity, coefficient of friction, running-in, conformability and strength properties of the bearing material, and hardness of the shaft surface.

—BRUNO SACHS
South Orange, N. J.

". . . check up on heat dissipation"

To the Editor:

Mr. Sachs is right regarding his Point 1. There is an error of omission in the sentence referred to. It was meant to read:

> As long as this value remains constant there can be no change in either oil film thickness or heat genera-

tion *for a given bearing* regardless of variations of load p and speed n.

With this wording, I am sure, Mr. Sachs will agree.

Point 2, is not clear since my article didn't assume a constant coefficient of friction in connection with the hydrodynamic theory. It merely pointed out the reasoning which led to the supposedly governing factors $pv \approx$ constant prior to the advent of the hydrodynamic theory. Otherwise my answer to Point 1 also covers Point 2. There is no disagreement.

As to the last paragraph of Mr. Sachs' letter, I heartily agree that the machine designer should check up on heat generation. It is also just as important to check up on heat dissipation. Alas, how?

—Arthur H. Korn
New York, N. Y.

". . . wood replaces metal"

To the Editor:

It is heartening to see how recent advances in utilization of wood is helping the metal conservation program. Many parts that formerly were metal are now being manufactured from wood by the same makers and are being advertised as such, requiring no priority rating.

High-density wood products such as Pregwood, Superpressed plywood, Compreg, Improved Wood, etc., (made by impregnating plies of wood with resins and bonding together in a hotplate press) are replacing metal in countless places. Density of the material and its strength characteristics can be varied by varying the amount of pressure and the impregnation. Thickness can be varied in different portions of the same assembly, as in the case of airplane propellers. Materials of this kind can be used and will be used for many parts in machines. In those places where designers have found them adaptable, the overall saving in vital metals has been great.

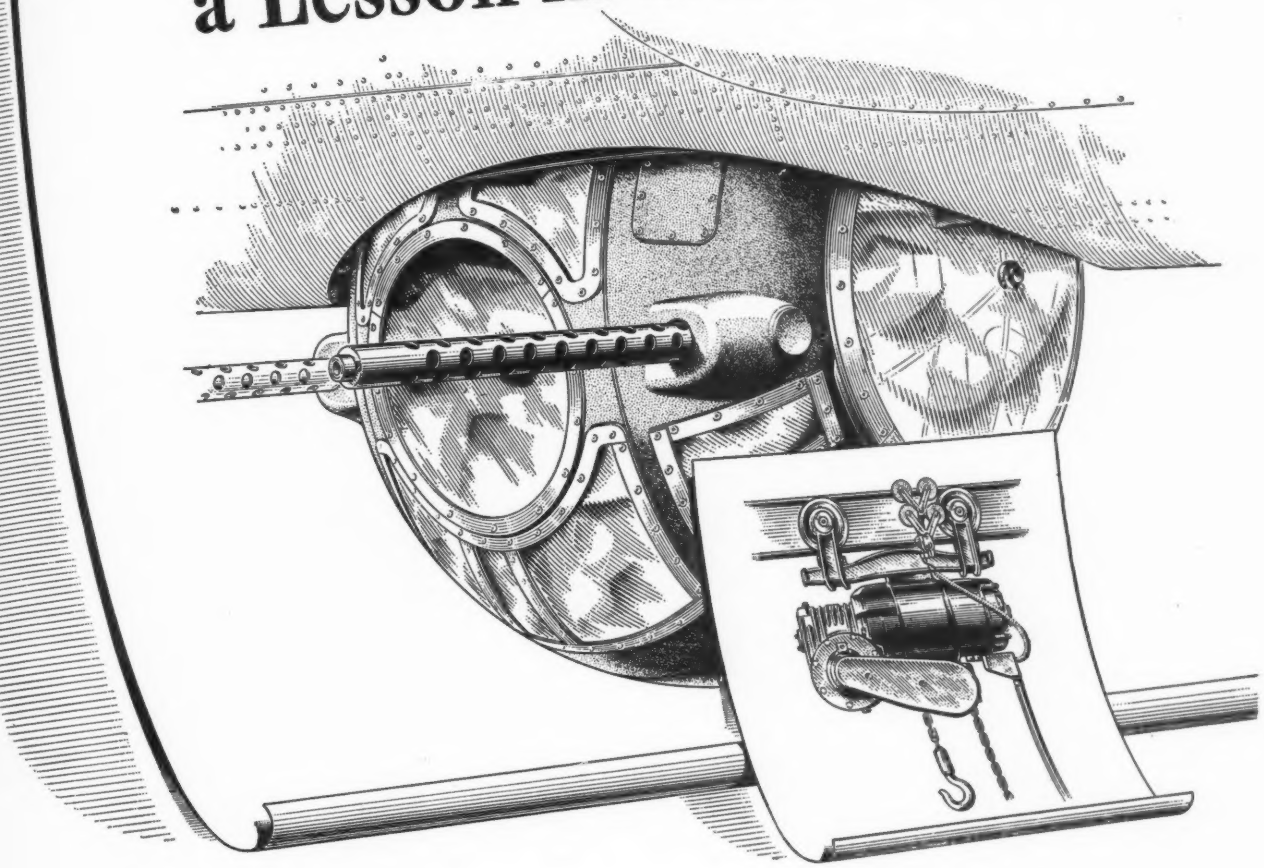
Lightness is incorporated with strength. That means something for portable and mobile equipment. Also, in the case of fast-reciprocating machine parts these light materials are useful. Even in machine gears, the new super-pressed plywoods are displacing other materials sorely needed in the war effort. The density obtained by the high degree of pressure and impregnation makes them amenable to machining on any gearcutting machine. Wood pulleys of the flat-face type have always been on the market and the improved wood materials now available are being used by some leading manufacturers of transmission equipment for V-belt pulleys also.

Wood has one tremendous advantage over most metals in its ability to withstand vibration without fatigue and consequent breakage. Hickory helves of riveting machines, maple pitmans and hickory picker sticks for the textile industry are examples. Wood has held its own remarkably under tension, too. Wooden sucker rods as used in many severe pumping installations typifying the extreme type of service encountered in these applications.

—John E. Hyler
Peoria, Ill.

BLACKOUT means more than just turning off the switch. If it is to be effective, safety measures must be employed. Blackout is to blind and confuse the enemy not demoralize ourselves. According to S. G. Hibben, chairman of the committee on Defense for the Illuminating Engineering Society, proper methods provide sufficient illumination for normal activity in factories and homes without letting telltale light leak through to enemy eyes.

The Plane Turret Found a Lesson in The Electric Hoist



There's not much in common, perhaps, between a hoist and a bomber turret. The hoist works day and night —constantly starting and stopping, frequently overloaded, seldom lubricated. That's why hoist manufacturers turned to the Torrington Needle Bearing to make product performance more dependable.

The plane turret, on the other hand, performs its task in a single, short, action-crowded interval, followed by thorough overhauling. But in those few swift moments of aerial combat, there's no leeway for the failure of *any* part. So turret designers, too, selected the Needle Bearing, to give reliable performance— and many other needed features as well. Quick response, for example, as the gunner pivots and somersaults to keep an enemy fighter in his sights—that comes from the Needle Bearing's low starting friction. A few more inches of space in the turret's cramped quarters, made possible by the bearing's small size. More rounds of ammunition or more gallons of fuel on board—result of the bearing's weight-saving features. And faster turret production because of the bearing's ready availability.

WHEN YOU DESIGN YOUR POST-WAR PRODUCTS, there may be a hint for you in a bearing as versatile as this. Long life, high load capacity, faster speeds, compact design, less need of attention—aren't these just the features your customers will be looking for? Torrington engineers will show you how you can give your product these advantages with the Needle Bearing. For preliminary information on sizes and ratings, and for a list of many typical applications, write for Catalog No. 109.

THE TORRINGTON COMPANY
Established 1866 • Torrington, Connecticut, U. S. A.
Makers of Needle and Ball Bearings
New York Boston Philadelphia Detroit
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LET'S GO! U.S.A. KEEP 'EM FLYING

TORRINGTON NEEDLE BEARINGS

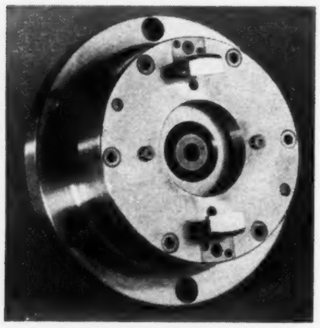
KEYED TO TODAY'S NEEDS

AND TOMORROW'S TRENDS

New PARTS AND MATERIALS

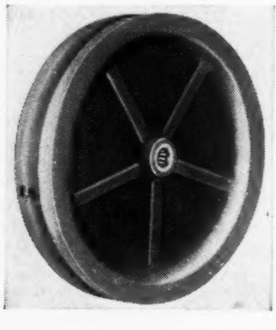
Air-Operated Finger Chucks

ADDED to the Airgrip holding device line of Anker-Holth Mfg. Co., 332 South Michigan avenue, Chicago, are special compensating type finger chucks. These air-operated chucks are so designed that one finger pulls in farther than the other, thereby compensating for varying thicknesses of pieces to be held. The design also permits pieces to be located from a fixed center stop position. Piece is driven by two fixed driving pins and the part is held against the chuck face by two "compensating" fingers. Chuck body is flanged and drilled for direct mounting on the spindle nose. Range of finger travel is adjustable to suit requirements. Available in a range of sizes the chucks may be operated by the company's high-speed revolving air cylinders, made in sizes from 3 to 18 inches inclusive. The chucks are furnished for second operation work to extremely close tolerances, and the one illustrated is for such work on M 61, 75-millimeter shell forgings. They also have many applications where standard three-jaw chucks cannot be used.



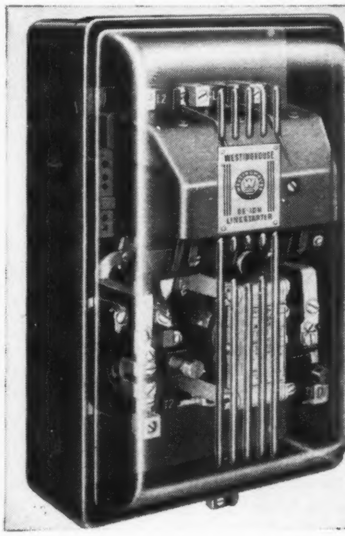
Pressed Steel Disk Wheel

SUITED to many duties on which rubber-tired wheels were formerly used, a strong, lightweight, roller bearing dual-disk pressed wheel has been develpoed by French & Hecht Inc., Davenport, Ia., for light and medium portable equipment. Of 10-inch diameter, the wheel consists of two pressed steel disks, steel rim and hub, all welded into a single wheel unit. Fair tire width permits travel over soft terrain. The wheels, it is claimed, will meet all requirements for light and medium portable equipment such as preheaters for bombers, portable welders, compressors, generators, battery chargers, mowers, milking machines, and small concrete vibrators.



Linestarter for Minimum Space

REQUIRING less than half the mounting space of former units, Westinghouse Electric & Mfg. Co., East Pittsburgh, has introduced its new Size 2 Class 11-200 linestarter for machine tools, textile machinery, pumps, fans and similar equipment. There is no sacrifice of wiring space in this compact linestarter which is designed for group mountings, built-in applications or remote mountings. The linestarter has a new clapper-type armature with knife-edge bearings. Double-break silver to silver contacts are utilized in the unit, eliminating shunts and reducing maintenance. Overload relays are reset either by hand or automatically. Where sequence or auxiliary interlocking is required, provision is made on the linestarter for a total of four normally-open or normally-closed electrical interlocks.



Manganese Base Alloy Offered

OFFERING several outstanding physical properties, a new manganese base alloy known as No. 772 is being introduced by W. M. Chace Co., 1600 Beard avenue, Detroit. Over 70 per cent of the alloy is manganese. This high manganese content and the resulting physical properties are made possible by use of electrolytic manganese of a purity higher than 99.9 per cent. The characteristics claimed for the alloy include a high electrical resistivity, a high thermal expansion rate, a high vibration damping constant and a low thermal conductivity combined with good ductility and high tensile

LS

rs for bombers, ttery chargers, vibrators.

Space

pace of former o., East Pitts- 200 linestarter ns and similar e in this com- ountings, built-

starter has a ngs. Double- e unit, elim- erload relays sequence or made on the or normally-

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erties, a new is being in- nue, Detroit. s high man- es are made urity higher for the alloy al expansion low thermal high tensile

March, 1943

★ "Mudding" the core for a vital aluminum casting . . . an important operation in speeding the production of Nazi Exterminating Equipment.

The skill and experience of this core and mold finisher, symbolizes the outstanding quality of Nationals' sand and permanent mold aluminum castings.

Good enough is not enough for Uncle Sam. That's why American fighting equipment is the best in the world. National aluminum castings are used in practically all of Uncle Sam's fighting equipment.

So, with slicks* in the hands of experienced men "pasting" and "mudding" cores, it's mud in your eye Schicklgruber.

**Name of tool used in pasting and mudding*

TENUAL

ALUMINUM CASTINGS

HE NATIONAL BRONZE & ALUMINUM FOUNDRY CO.

CLEVELAND, OHIO

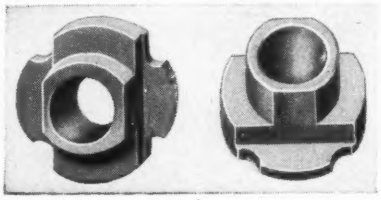
NEW YORK—111 Broadway • CHICAGO—188 W. Randolph • DETROIT—Stephenson Bldg. • LOS ANGELES—405 S. Hill

AKERS OF QUALITY SAND AND PERMANENT MOLD ALUMINUM CASTINGS

strength. Electrical resistance is 1050 ohms per circular mil foot. The physical properties of the material enable it to be used for such low temperature resistor applications as rheostats, auxiliary heaters for circuit breakers, and electrically heated expansion elements. Use of high thermal expansion rate of the alloy has resulted in improved thermostatic bimetals, and offers the same possibilities for other types of differential expansion mechanisms. The low thermal conductivity permits use of the material for parts of soldering irons, circuit breakers and other equipment in which heat barriers can be used. The alloy can be fabricated by usual rolling, drawing and machining operations, and is available in sheets, strips and rods.

Enlarge Powder Metal Line

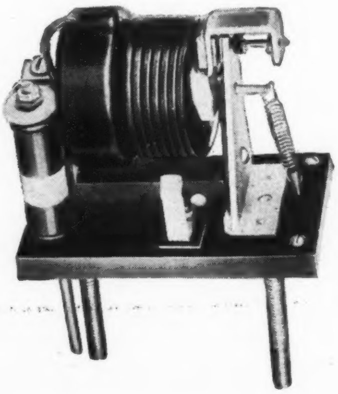
SMALL powder metal parts of special design and shape which eliminate machining operations are being included in the line of Keystone Carbon Co., 2027 State street, St. Marys, Pa. These parts which formerly needed considerable machining, are now being produced by the company by



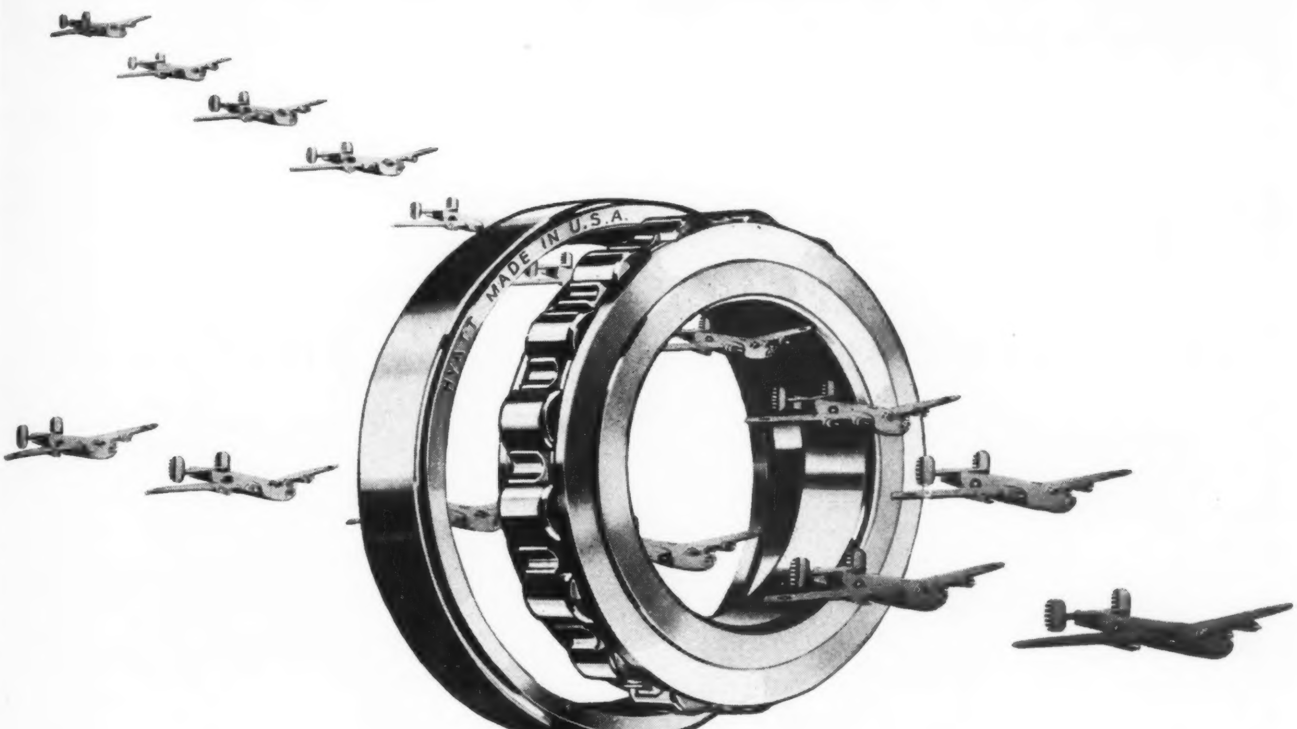
powder metallurgy. Typical of the small metal parts are: Cams, eccentric parts, levers, rotors, slide blocks, and other similar parts. Tolerances are readily maintained in these parts, and moving units can be prelubricated for improved resistance to wear. The process permits the use of alloys, and porosity and specific gravity can be acquired to exact specifications.

Battery-Cutout Relay Announced

FOR use in ship service and in any application where batteries are charged from generators, a new automatic battery-cutout relay, Type HAP, is now being marketed by General Electric Co., Schenectady, N. Y. It performs practically

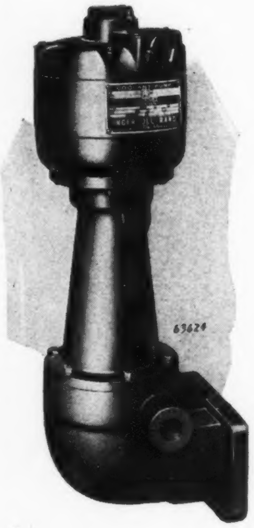


the same function as a circuit cutout device in an automobile. When battery voltage is lower than that of the starting source, the relay closes the charging circuit. When charging


HYATT MADE IN U.S.A.

voltage drops to a value below the battery voltage the new cutout relay opens the circuit on a small reverse current. Available continuous current ratings are: 2.5, 4, 6.5, 10, 16, 25, 40, 65, and 100 amperes. Voltage ratings are 7.5 volts (3-cell batteries) to 300 volts (120-cell batteries). Relay is set to pick up at slightly below the normal charging voltage.

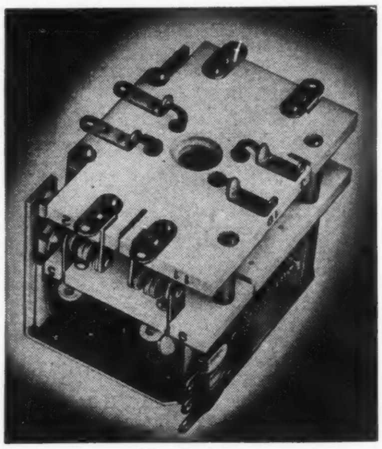
Circulatory Pumps Announced



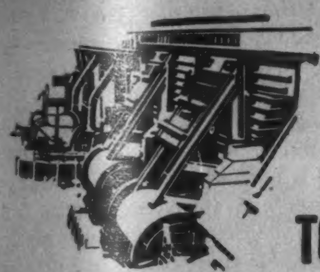
SUITABLE for installation on machinery requiring a coolant or circulatory unit, a number of new pumps have been announced by Ingersoll Rand Co., 11 Broadway, New York. In the new line are included ¾-inch and 1-inch side - wall - mounted types, a 1¼-inch side-wall-mounted type for low-submergence applications, and a 1¼-inch horizontal type. Besides being applicable to lathes, drills, automatics, cut-off machines, and grinders which require a constant supply of coolant fluid or cutting oil, they can be used for evaporative condensers, air-conditioning units, washers, etc. The new pumps are an addition to the line of coolant pumps previously available which include ¾-inch, 1-inch and 1½-inch immersion-type pumps and a 1¼-inch side-wall-mounted type.

High-Speed Aircraft Relay

FOR aircraft radio equipment Model AK relay has been compactly designed by Allied Control Co., 227 Fulton street, New York, for high voltage, high speed and resistance to vibration. Its push-pull magnetic arrangement provides magnetic holding pressure on both transmit and receive con-

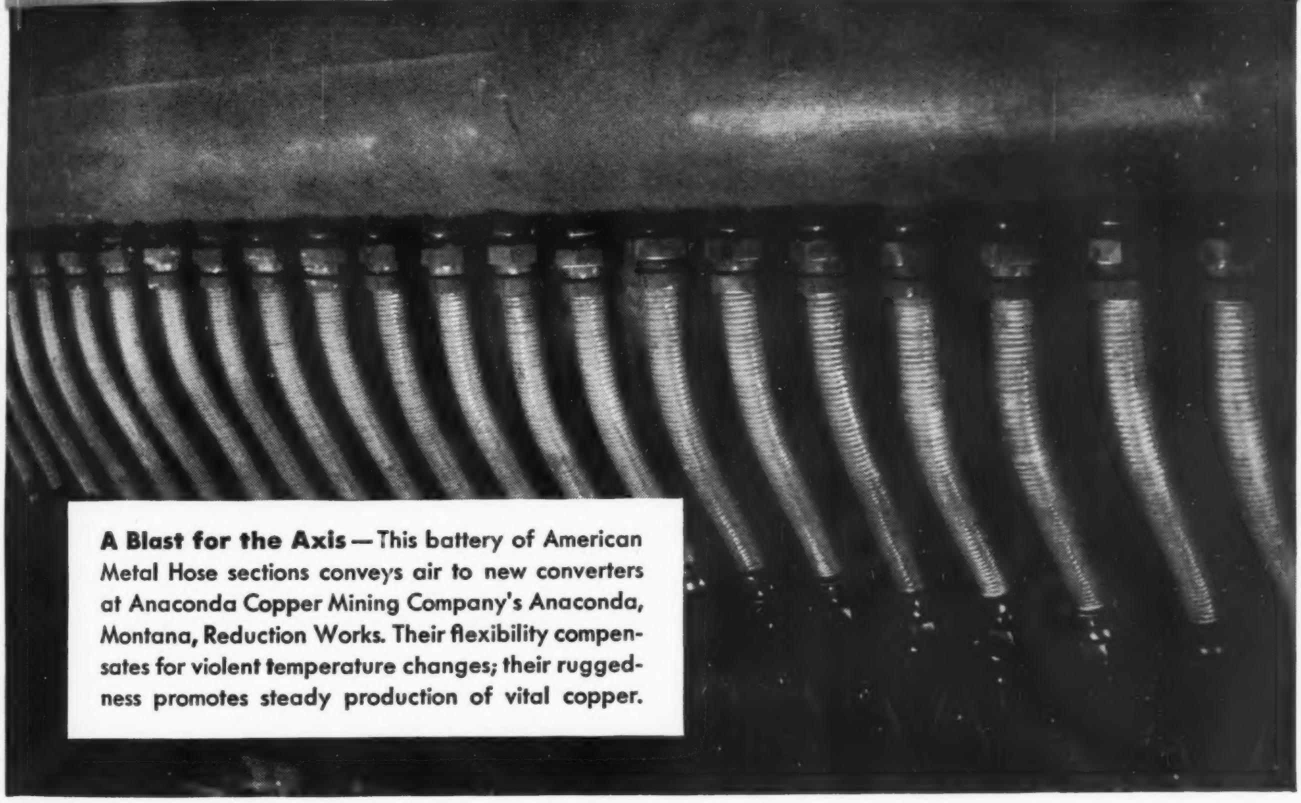


tacts. One pole is equipped with two windings, one of which is a holding winding connected directly across the battery supply. The other is connected in series with the single winding on the other pole and polarized so that when the circuit is completed through the key, the flux is neutralized on the



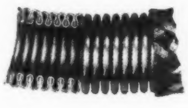
Hose that conveys cold air under 15 lbs. pressure

TO FURNACES HOLDING TONS OF MOLTEN COPPER



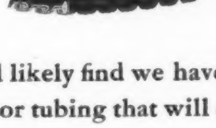
A Blast for the Axis—This battery of American Metal Hose sections conveys air to new converters at Anaconda Copper Mining Company's Anaconda, Montana, Reduction Works. Their flexibility compensates for violent temperature changes; their ruggedness promotes steady production of vital copper.

One of the most attractive features of flexible metal hose and tubing is its seemingly endless range of application. Using virtually any workable metal, we can build flexible hose or tubing for almost any purpose—from a simple spout to a high pressure seamless hydraulic line that can be flexed millions of times without breaking—a line that will give you the flexibility of garden hose, the dependability of metal and the *strength of rigid pipe!*



American Seamless — corrugated from seamless rigid tubing ... no welds, laps or joints...made in several alloys.

Whether you need a flexible connector for misaligned or moving parts, for isolating vibration, for conveying air, water, oil, steam or fuel, you'll likely find we have a type of flexible metal hose or tubing that will do the job more capably.



American Interlocked —wound of strip metal, joints packed; the toughest type of extremely flexible metal hose.

43197

ANACONDA

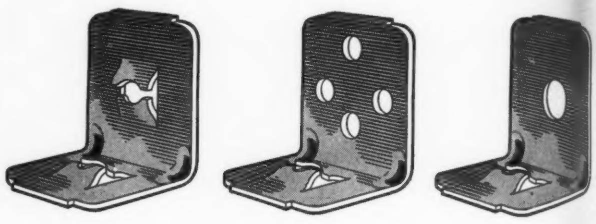
American Metal Hose

AMERICAN METAL HOSE BRANCH OF THE AMERICAN BRASS COMPANY • General Offices: Waterbury, Conn.
Subsidiary of Anaconda Copper Mining Company • *In Canada:* ANACONDA AMERICAN BRASS LTD., *New Toronto, Ontario*

holding or receiving-position pole and the armature pulls up to the transmit position. The bucking flux is cut off by opening the key, and the holding flux pulls the armature back to receive position. Relay is completely balanced, and its arms are equipped with antibounce features. It keys at 30 cycles, and its contact rating is 1000 volts at 30,000 feet, 20 megacycles, 4-pole double-throw. Insulated to sustain 10,000 volts at sea level the relay is furnished in standard models in 12 and 24 volts direct current. Wattage consumption is 5.5 in first position and 17.0 in second. It withstands vibratory motion to better than 20 G. Mounted with elastic stop nuts, the relay measures 2 7/16 x 3½ x 2¼-inch and weighs 17 ounces. All of the terminals of this high-speed relay are easily accessible. The insulation plate is produced of high-pressure stearite material.

Bracket and Fastener Combined

NEW angle brackets with self-contained fasteners are now being produced by Tinnerman Products Inc., 2085 Fulton road, Cleveland, to speed up angular attachments and reduce weight in aircraft and other war equipment. The outstanding feature of the bracket is an integrally formed



speed nut in one or both sides of the bracket according to the requirement of the application. The combination bracket is made for 8Z and 10Z Air Corps sheet metal screws and standard rivets. When used in connection with conduit and piping this new bracket also permits the use of standard bonding clamps in place of ear-type aluminum bonding clamps. The fact that the nut is a part of the bracket reduces the number of parts as well as weight. The new bracket is already in use in aircraft plants that previously manufactured their own plain brackets and assembled them with separate self-locking nuts.

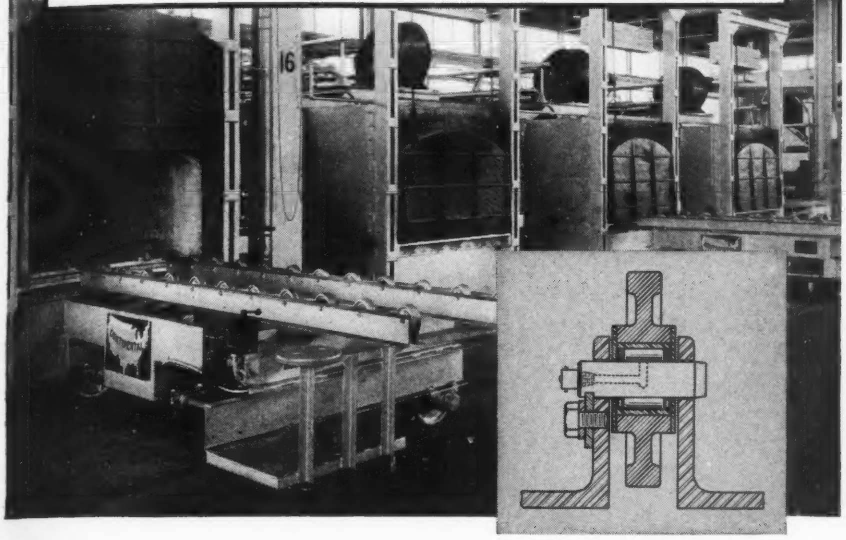
Relay Developed for Aircraft

DEVELOPED by the G-M Laboratories, 4326 North Knox avenue, Chicago, the new 3PDT Type 27 relay is intended particularly for aircraft use but also has advantages for other specialized uses. The relay measures 2 x 1⅞ x 2⅛-inch and weighs 5 ounces. Its characteristics are: Acceleration, 15 g-plus; nominal coil voltage, 12 volts direct current; pick-up 6.5 volts (.92 watt) at 20 degrees Cent.; coil wattage at 12 volts direct current, 3.2 watts; contact pressure, 60 grams; contact capactiy, 10 amperes at 30 volts direct current; and temperature rise is 32 degrees Centigrade at 12 volts direct current.

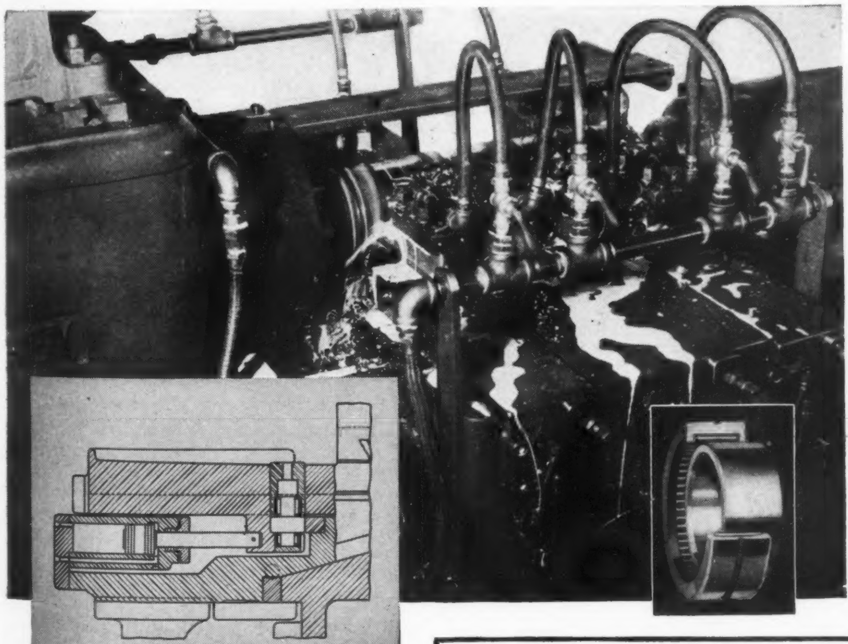
Electronic Spot Welding Control

FOR precise operation of resistance-welding machines, a new electronic half-cycle, synchronous control is being offered by General Electric Co., Schenectady, N. Y. The control, mounted in a protecting cabinet, is available in two types:

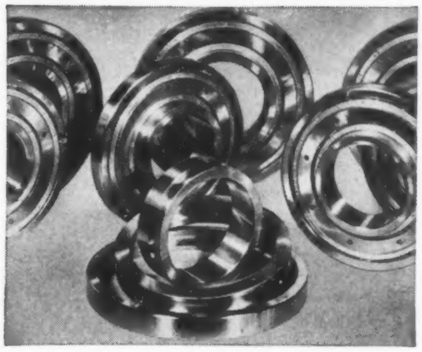
IN THE NEWS WITH BANTAM BEARINGS



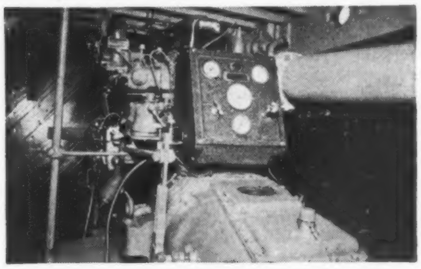
TO SPEED THE ANNEALING of iron alloys, these furnaces built by Continental Industrial Engineers, Inc., are designed for rapid handling of the work. Metal to be heat treated glides smoothly into the furnace on easy-turning rollers. As shown in cross-section, each roller turns on an anti-friction bearing unit assembled from Bantam Needle Rollers. A hardened sleeve, also furnished by Bantam, forms the outer raceway.



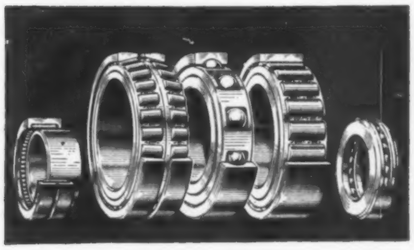
IN MACHINE TOOLS, the Quill Bearing's small size, high capacity, low friction coefficient, and efficient lubrication make it possible to combine long life, low power consumption, and compact product design. A typical instance is the use of Quill Bearings on the front carriage assembly of Semi-Automatic Shell Lathes built by Morey Machinery Co., Inc. For further details on this unusual anti-friction bearing unit, write for Bulletin B-104.



DESIGN OF SPECIAL BEARINGS is an important aspect of Bantam's service in meeting unusual requirements. These triple-race radial ball bearings were designed to eliminate starting friction in dynamometers, where this variable factor would seriously affect the accuracy of the test results. Very close dimensional tolerances were maintained in these bearings as an added assurance of accurate results.



IN MARINE APPLICATIONS TOO, Bantam Bearings play their part in improving product performance. Twin Disc Clutch Company uses Bantam Bearings for the throwout bearing on its widely used Marine Reverse and Reduction Gears, one of which is shown here on a 215-HP engine.



WHEN LARGE-SIZE BEARINGS ARE NEEDED, Bantam's experience in the design and manufacture of heavy-duty bearings is of special value. Bantam's line includes every major type of anti-friction bearing—in sizes up to the largest ever built. If you have a problem involving exceptionally severe bearing requirements, TURN TO BANTAM.

ARMY E NAVY

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION · SOUTH BEND · INDIANA

SUBSIDIARY OF THE TORRINGTON COMPANY · TORRINGTON, CONN.

CR7503-A136, which also includes a welding transformer and is designed for bench mounting, and CR7503-A133 which is without a transformer and designed for wall mounting. Both can be used either with tongs or a suitable bench welder. In this control are featured the new GL-445 tube, a new circuit for high-speed welding, and a simplified initiating circuit for improving performance and reducing maintenance. The new design also incorporates heat control by the phase-shift method. Heat adjustment is made by a dial mounted on the front of the cabinet. The control facilitates welding of tinned copper, steel or alloy wires, of studs to flat surfaces, with little or no indentation on the opposite surface of the metal; and the spot welding of unusually thin pieces of stainless or mild steel, nickel, or silver to brass or bronze, with negligible oxidation or discoloration. With this control it is also possible to weld low resistance joints which are unaffected by temperatures in excess of 125 degrees Cent., the point at which certain types of soldered joints weaken and often collapse, resulting in complete elimination of solder, with a corresponding saving of tin.

Solenoid Motor Starter Available

MANY new features have been added to the new thermaload V solenoid motor starter recently announced by Monitor Controller Co., Baltimore. The most notable feature is the bimetal compensated overload relay which per-

mits perfect starter operation under extremes of ambient temperature. Full overload protection is obtainable because the trip occurs within the same time at a given percentage of overload. Safeguarding the motor, a unique arrangement prevents operator from improvising any method to hold the starter button in the "on" position, thus preventing the trip when overload occurs. The operator must press the button and release it before contact is made. The starter measures 5¾ x 5¼ x 4⅛ inch. Some of the other features are its resilient, shockproof mounting which eliminates objectionable hum, double-break contacts of pure silver, and easily interchangeable coils for different voltages. It is available in five sizes—1.5 to 7.5 horsepower for 110 to 550 volts alternating current services. This new thermaloid V solenoid motor starter has been tested and approved by the Underwriters' Laboratory, and it meets overload time specifications.

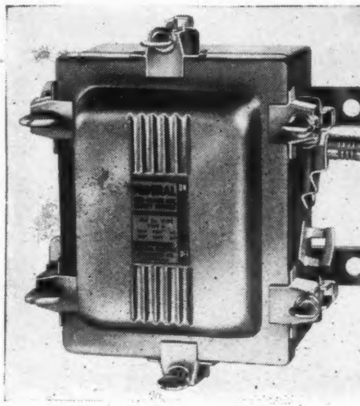
General Purpose Limit Switch

AN ANNOUNCEMENT has just been released on a new type LS limit switch of roller arm, spring return type, by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. This switch is designed primarily for making and breaking com-

trol circuits or indicating circuits at a fixed point in the operating cycle. Replaceable double-break self-aligning silver-to-silver contacts are used for long life and dependability in operation. A set of normally open and a set of normally closed contacts are included. Built for heavy-duty applications, the switch is protected from accidental damage by a heavy cast-iron enclosure. All wearing surfaces are hardened steel or made of special alloys, and all corrodible parts are cadmium-plated. Operating arm of the switch can be set in any one of thirty positions, and is available in two sizes. Standard arm is 2¼-inch and the short arm 1½-inch between center.

Safety Switch Is Dust-Tight

WEATHERPROOF, dust-tight, heavy-duty safety switches, announced by Federal Electric Products Co., Newark, N. J., are designed for use in grain elevators, steel, chemical, brewery, ordnance, woodworking, textile and flour industries. Both cover and enclosing case are cold rolled sheet steel which decreases weight. Covers are fastened to case by heavy corrosion-proof eye-bolts and wing nuts, the eyebolts acting as hinges on the left side of switch. A heavy rubber gasket between two layers of steel on inside surface of cover increases weatherproof and dust-repelling qualities of the switch. In-



terlocking covers are standard. Two tapped conduit entrances of the proper size are furnished with all enclosures. The 30 ampere switches have one hub for ¾-inch conduit on top and bottom; the 60 ampere sizes have one hub for 1¼-inch conduit; the 100 ampere sizes have two hubs for 1½-inch conduit; and the 200 ampere sizes have two hubs for 2½ inches conduit in top and bottom. To facilitate drilling of additional holes, reinforced pads have been placed at sides and top. If specified, two additional holes will be drilled where pads are located. Maximum size possible for these drillings for 30 and 60 amperes is 1½ inches, for 100 and 200 amperes, 2¼ inches.

Motor-Driven Reset Timers

SYNCHRONOUS motor-driven timers of the reset type are available through R. W. Cramer Co. Inc., Centerbrook, Conn., for time ranges up to five hours and longer. Having a wide application for timing electrical circuits such as the automatic timing of machine operations, chemical and food processing or heating processes, these timers repeat their time cycle upon manual operation of a built-in start button. Two types are available, the RS4 and RS5. The former has a double-throw switch and open or closes the circuit, depending upon choice of circuit, and starts by pressing and then releasing the start button, which also resets the timer. The

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RS5 is different in that it is mechanically held in a neutral position when button is depressed and starts the timing cycle by pulling start button outwardly. Encased in black bakelite cases for flush panel mounting, the timers operate a single-pole, double-throw switch with a capacity of 10 amperes at 115 volts or 5 amperes at 220 volts alternating-current non-inductive load. They will control a 1/3-horsepower motor load, a heater load of 1200 watts, a lamp load of 250 watts or a relay load which does not exceed 15 amperes inrush at 115 volts alternating current. The timers measure 3¼-inch in diameter and about 4½-inch in overall length, and can be supplied in dust or moistureproof surface mounting steel housings as well as in explosionproof cases arranged for conduit connections. They can also be had with built-in visual or audible signals.

Engineering Dept. Equipment

Compass for Small Circles

FOR draftsmen and metal workers a new instrument for scribing and drawing small circles a few thousandths to ⅝-inch radius has been brought out by the Ithaca Scientific Instrument Co., Ithaca, N. Y. This compass was developed to overcome the difficulty encountered in attempting to scribe small circles with dividers. The pencil adapter in the compass furnishes the draftsman with an improved rivet compass. Tilting the compass makes it draw an ellipse, which characteristic makes it possible to blend curves with tangents when center is slightly out of position. When using pencil adapter the worn clamp nut is tightened until snug to avoid trouble from backlash but not enough to injure the worm gear when setting. For maximum rigidity and accuracy, the compass is used with scribing needle as short as work will permit. For largest circle, scribing needle is set to its greatest length. The compass is furnished in a durable case, complete with scribing needle, pencil adapter and a supply of leads.

Waterproof Ink for Drawings

AVAILABLE in twenty-three colors, a drawing ink has been developed by Louis Melind Co., 362 West Chicago avenue, Chicago. It is a free-flowing waterproof ink which lends itself well to reproductions, inasmuch as a fine line may be drawn without feathering or bleeding. The claim is made that the ink will not cake in bottle, or brush

Designing Molded Plastics Parts: MOLD DESIGN CONSIDERATIONS

From the engineering files of One Plastics Avenue

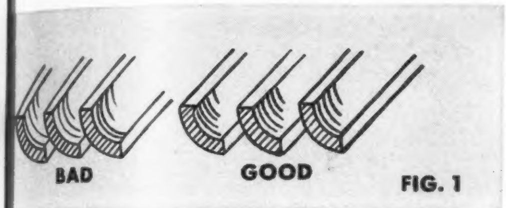


FIG. 1

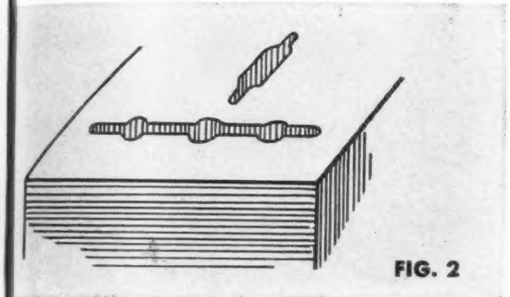


FIG. 2

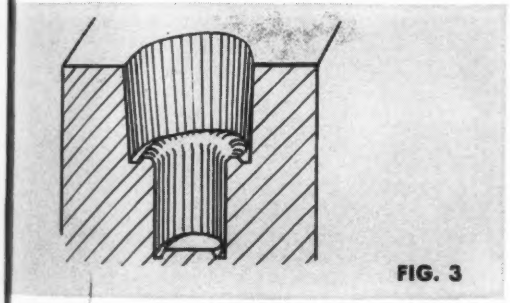


FIG. 3

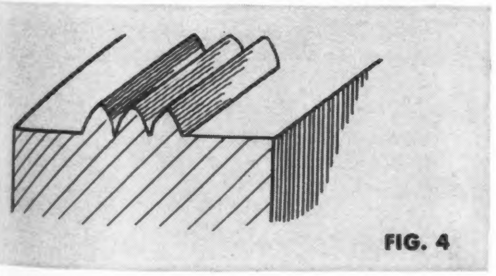


FIG. 4

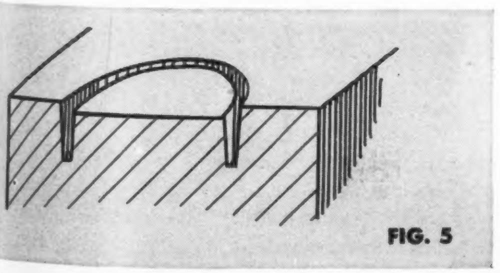


FIG. 5

Practically any design can be molded, but adherence to approved standards will give more serviceable and more economical parts. Considerations which make for better mold design are as follows:

1. Sharp corners, unless produced in a mold built up of sections or unless located at the cutoff, require extra expensive die work. Deep barriers and fins likewise require difficult mold work.

2. In forming grill sections, etc., avoid passing two mold sections so close as to require a vertical cutoff. (Fig. 1)

3. Deep slots or keyways must be molded by long thin rectangular pins; round out the center portion to strengthen the mold pin if possible. (Fig. 2)

4. Pins, wedges and threaded plugs which must be removed from the mold during the molding cycle are likely to become nicked and rounded over. If possible, provide fillets and grooves in the molded part to allow ends of pins and wedges to become rounded over, or to allow shoulders on the tools to absorb abuse. (Fig. 3)

5. Avoid molded parts which necessitate delicate mold sections such as shown in Figs. 4 and 5.

ONE PLASTICS AVENUE at Pittsfield, Massachusetts, is the headquarters for five plants of the Plastics Department of General Electric Company. It signifies the location of complete plastics facilities for development, material manufacture, designing, engineering, moldmaking, molding and laminating.

REPRINTS of this advertisement may be obtained by writing Section E-3, General Electric, Plastics Department, One Plastics Avenue, Pittsfield, Mass. Also available upon request is a 16-page folder on designing molded plastic parts.

PD-23

PLASTICS DEPARTMENT

GENERAL ELECTRIC

or pen. While in use for over two years by governmental agencies, it is only now being offered to the general public. The ink is available in ¾-ounce, quill-stopper bottles, and also in 4, 16 and 32-ounce containers.

V-Construction Drawing Tables

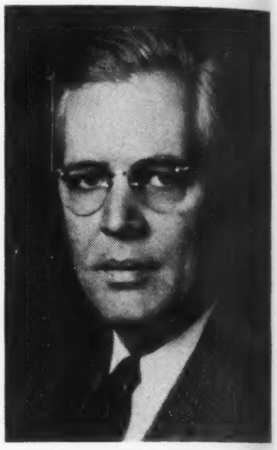
V-CONSTRUCTION wooden tables are now being offered by Engineering Sales Co., Sheboygan, Wis., replacing steel construction ones. The drawing top is five-ply solid basswood lumber core with two plies of basswood on face and back in ¾-inch thickness. It is a one-piece top, eliminating seams, cracks and joints. Base is heavily constructed and finished in olive green to resemble steel. Tilt of drawing table is adjustable to any angle from vertical to horizontal with a simple positive clamping device. Height is adjustable from 32 inches to 39 inches. The tables are offered in sizes from 21 x 26 inches to 24 x 36 inches. Two other special models No. V8003 (regular construction) and No. V8003X (extra heavy construction) are offered with tops 30 x 42 inches. The

telescopic tilting device in these models provides for greater strength and rigidity. The tables are otherwise similar to the regular models. Three types of tops are available: Plain five-ply with natural water-proof finish with no straightedge or parallel ruling device; five-ply top with waterproof finish and built-in parallel ruling device, with plain bakelite straightedge not having transparent edges; and five-ply top with waterproof finish and built-in parallel ruling device, equipped with bakelite straightedge having transparent plastic edges.

Resilient Drawing Board Tops

TO RELIEVE conditions in drafting departments, W. H. Long Co., 425 North Clark street, Chicago, has announced its new drawing board tops known as "No-Ink". This top is a specially processed white composition ⅛-inch thick, which may be permanently glued to any drawing board. A 3-H or harder pencil can be used. The drawing surface is resilient, allowing paper to be indented under slight pressure of pencil. All lines are drawn with a double stroke. The microscopic indentation made by the first stroke is filled with lead by the back stroke which results in a solid, opaque line. Due to the use of hard lead, lines do not smudge when drawings are worked over for any length of time. While the top yields to pressure of pencil, indentations disappear and needle holes made by compass also close up. It is chip-proof and washable, and is available in any required size to fit drawing boards.

MEN OF MACHINES



AFTER twenty-eight years with the Geo. D. Roper Corp., Rockford, Ill., S. H. Hobson was elected a member of the board of directors and president of the company, succeeding the late Mabon P. Roper. Well known to the industry, Mr. Hobson has moved up progressively from assistant foreman to the presidency. From 1919-1929 he was chief engineer and supervised various undertakings of the company. When the Roper-owned Blackhawk Engineering Co. was formed in 1941, Mr. Hobson was made president of this company. He continued, however, to act as executive vice president of the Geo. D. Roper Corp. until his present appointment. In view of his lengthy connection with the company, Mr. Hobson is in position to maintain its long-established policies.

RECENT changes in the gear department of General Electric Co., Lynn Works, includes the retirement of A. A. Ross as engineer and the appointment of E. N. Twogood to replace him. Mr. Twogood has been executive assistant to Mr. Ross since 1923. He was born in Fulton, South Dakota in 1833 and was graduated from the University of California

in 1910 with electrical and mechanical engineering degrees. In the same year he entered the test course sponsored by the General Electric Co. He became a member of the turbine department in 1916, and in seven years was transferred to the

metal gear and pinion department at Lynn, Mass.

Mr. Ross, who is retiring, was born in Nova Scotia, Canada, in 1876 and has been with the company since 1894. In 1913 he was transferred to the Lynn River works where he was gear and pinion specialist. His appointment as engineer of the gear department came in 1923. During his retirement he will devote part of his time to the company as a consultant. He is a past president of the American Gear Manufacturers association. In the accompanying photograph Mr. Ross is shown at the left, Mr. Twogood at the right.

E. B. Pool has become associated with the Dodge Chicago Aircraft Engine division as supervisor of physical testing.

E. H. Dix Jr., chief metallurgist, and R. L. Templin, chief engineer of tests, have been named assistant directors of the Aluminum Research Laboratories, New Kensington, Pa.

Ethan A. Berry has joined the Empire Ordnance Corp., Philadelphia, as engineer. He had been connected with the Chicago Pneumatic Tool Co.

Associated with Chambersburg Engineering Co. as vice president since 1934, Commander R. E. W. Harrison, U.S.N., has been recalled to active duty and will be in the office of the Under-Secretary of the Navy, serving directly under Admiral H. G. Bowen. Commander Harrison had been in temporary inactive duty and had returned to Chambersburg in July, 1942. He was born in Manchester, England, in 1893. After graduation he joined the Churchill Machine Tool Co. Ltd., where he remained until the World War. Serving in the 42nd Division of the Royal Engineers during the war he afterward joined the Signal Corps and held a commission. Then until 1926 he was connected again with the Churchill organization. At this time he came to the United States and became a member of the engineering staff of the Cincinnati Milling Machine Co., later becoming chief engineer and director of Cincinnati Grinders Inc. Commander Harrison holds a number of patents on precision grinding machine applications and has contributed a number of papers to the proceedings of technical societies.

M. H. Kapps, who had been connected as research engineer with Carter Carburetor Corp., is now project engineer at the Diesel Engine division of General Motors Corp.

Prof. Robert Meiklejohn has been appointed acting chairman of the department of engineering drawing, Ohio State university.

W. A. Schlegel of the metallurgical department, Carpenter Steel Co., Reading, Pa. has been awarded the Henry Marion

(*Continued on Page* 148)

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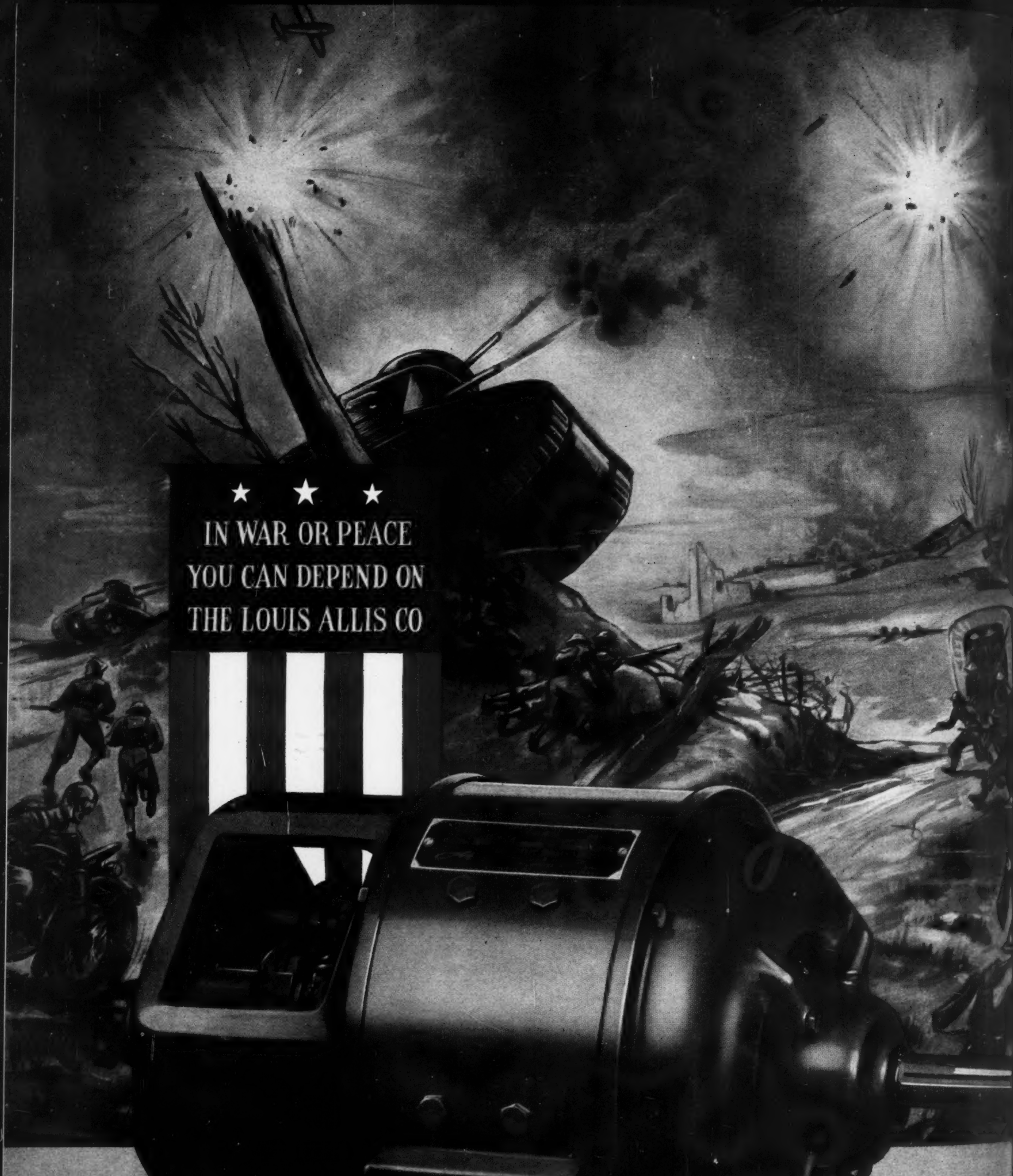
IN WAR OR PEACE
YOU CAN DEPEND ON
THE LOUIS ALLIS CO

(*Continued from Page* 142)

Howe gold medal by the American Society for metals, for his technical paper on "Surface Carbon Chemistry and Grain Size of 18-4-1 High Speed Steel."

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GENE D. SICKERT has recently been made chief engineer of Perfex Corp., Milwaukee.

•

WILLIAM A. HEINE JR. has left his position as automotive engineer with Tide Water Associated Oil Co., to become chief engineer of Acromark Corp., Elizebeth, N. J.

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WOLFGANG E. SCHWARZMANN has become consulting engineer for the American Bosch Corp., Springfield, Mass. He prieviously was chief engineer of the Aviation division of the company.

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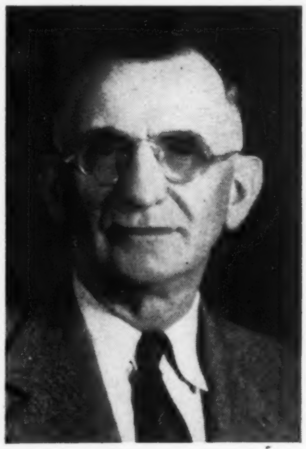
VERNE S. WHITE, who had been project engineer, Aircraft Engine division, Continental Motors Corp., has become design engineer of Ford Motor Co., Dearborn, Mich.



ENGINEER since 1908 at Westinghouse Electric & Mfg. Co., David Hall has recently retired. Mr. Hall has headed engineering activities for the company in the Los Angeles area since 1926, and served as engineering supervisor until mid-1941, when he was named assistant to the Pacific coast district engineering manager and assigned to special work. Mr. Hall was born in Tennessee and was graduated from Lehigh university as an electrical engineer in 1896. He entered the electrical industry the same year and joined Westinghouse at East Pittsburgh eight years later. Until 1926 he was active in the design and construction of direct-current equipment in the power engineering section. He also played a prominent part in designing and building equipment which made electrification possible. For many years he was responsible for the design of large direct-current machines, and helped develop the first practical direct-current drive for the Pacific coast oil drilling operations. Mr. Hall has also for the past ten years served as special lecturer on electrical machine design at the University of Southern California.

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SYLVAN EUGENE BURKE, formerly tool designer at Wright Aeronautical Corp. has joined the Propeller division, Wickwire Spencer Steel Co., New York city, as chief tool designer.

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JAMES W. CARL has been promoted to the post of mechanical engineer at Cleveland Pneumatic Tool Co., Cleveland.

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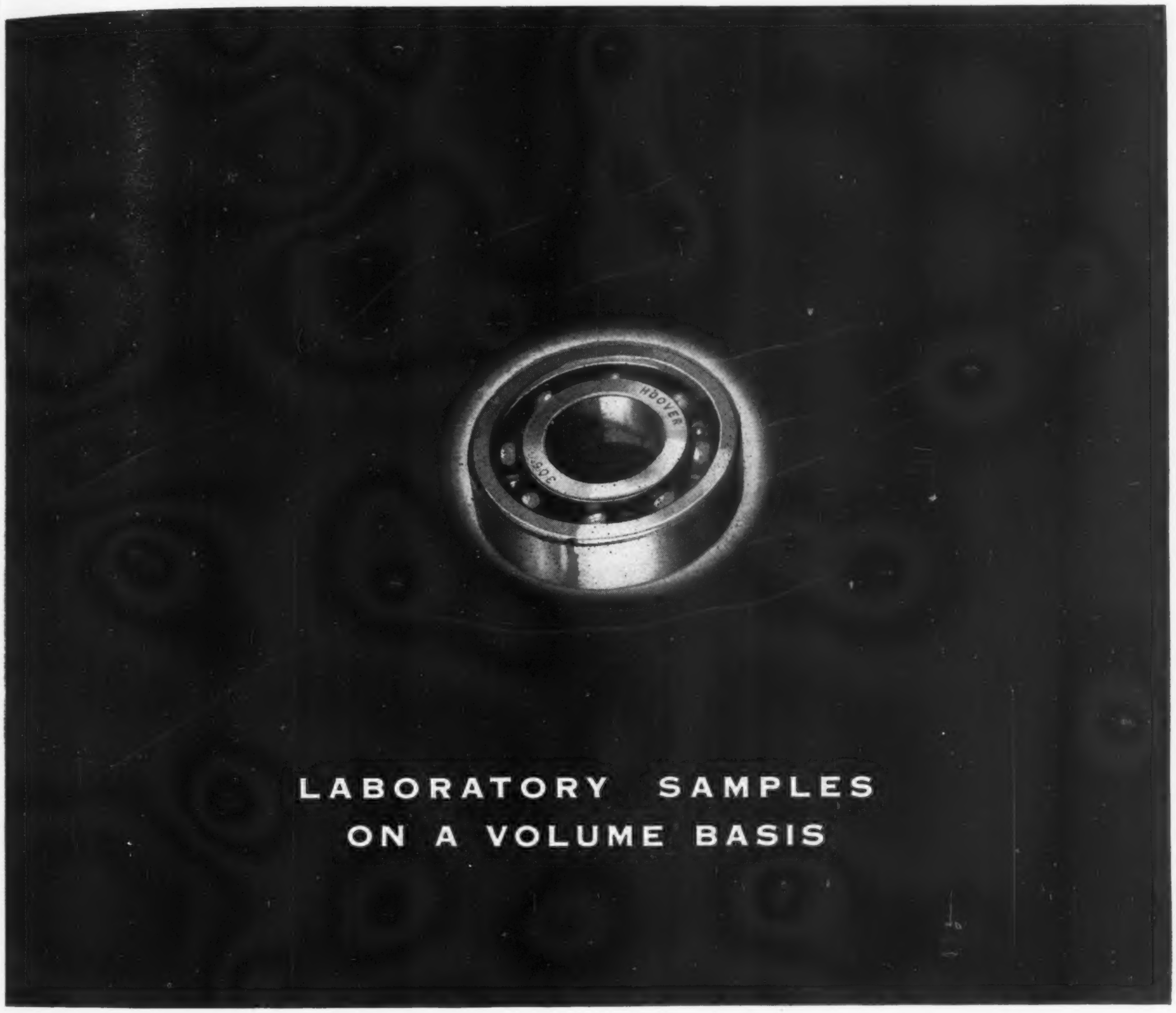
DR. CHAO-CHEN WANG, twenty-eight year old Chinese de-



UNTIL recently Ball Bearings with honed raceways were only available as handmade laboratory samples. These samples sparkled and shone like precious jewels . . . **and were almost as expensive!** And then Hoover engineers, after years of research, announced a method of honing the raceways of ball bearings mechanically, and on a volume basis. The result is America's only bearing with honed raceways . . . raceways with a degree of uniformity, and exactness in precision, smoothness, and quietness, previously only attained in expensive handmade samples. It means that when you select Hoover Ball Bearings your bearing dollars buy increased load capacity, extended life, higher allowable speeds and many other advantages contributed by this exclusive feature. And the cost is so reasonable that these improved bearings may be adopted as standard equipment on all commercial products of quality.

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HOOVER
BALL AND BEARING COMPANY
ANN ARBOR, MICHIGAN

Manufacturers of
BALLS, BALL BEARINGS, ROLLER BEARINGS

HOOVER *The Aristocrat of Bearings*

sign engineer, is at work in the electronics laboratory of Westinghouse Electric & Mfg. Co., designing high-power radio tubes. Dr. Wang has enlisted for the duration as a member of "America's production army."

Harold W. Ager Jr. automotive engineer, has become an automotive technician in the U. S. War Department, Desert Training Center, Camp Young, Calif.

Paul Louis Smith, an engineer at Douglas Aircraft Co. Inc., Santa Monica, has been appointed assistant methods analysis engineer of the company.

Francis P. O'Connell, who formerly was a technician in the development department of Baldwin Rubber Co., Pontiac, Mich., has been made inspector of ordnance materiel at the Detroit Ordnance district.

Dale Emmet Wilkins has been made assistant project engineer on turbo-superchargers, Wright Aeronautical Corp., Paterson, N. J. Previously he was senior test engineer.

Woodrow L. Wroblewski has recently joined the Briggs Mfg. Co., Detroit, as stress engineer. He held a similar position with the Eastern Aircraft division, General Motors Corp., prior to his new connection.

Arthur R. Parilla, who formerly was chief engineer of Chicago Pneumatic Tool Co., Garfield, N. J., is at present working on special assignments for the Eastern Aircraft Division, General Motors Corp., Linden, N. J.

Francis Galdo has accepted a position as designer with Associated Designers, Birmingham, Mich. He had previously been connected as designer with the Yellow Truck & Coach Mfg. Co.

J. M. Luther has become assistant chief engineer of Globe Aircraft Co., Fort Worth, Tex. He had previously been associated with the Curtiss-Wright organization.

Frank Silloway has been elected president of the Farm Equipment Institute. Vice president of Deere & Co., Moline, Ill., Mr. Silloway served as chairman of the institute's executive committee.

William J. Simpson has joined the engineering staff of Milton Roy Pumps, Philadelphia, manufacturers of chemical high-pressure and controlled-volume pumps. A graduate engineer of Pennsylvania State College, he has for several years been design engineer for Baldwin Locomotive Works, Baldwin-Southwark Corp. and Brill Car Co.

Charles F. Wagner and Dean Harvey, veteran engineers, have been honored by Westinghouse Electric & Mfg. Co. for their outstanding contributions to the electrical industry, by being awarded the company's Order of Merit. Mr. Wagner was honored for his lightning studies, while Mr. Harvey was given recognition for his contribution to the war effort as a member of the conservation division of the War Production Board. Mr. Wagner is manager of central station engineering and Mr. Harvey is materials and standards engineer.

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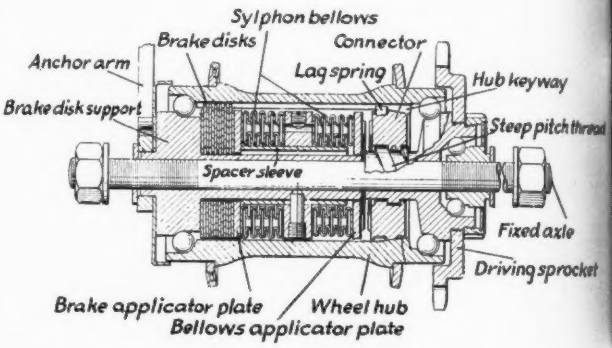
March, 1943

Noteworthy Patents

Coaster Brake Goes Hydraulic!

COASTER brakes for bicycles or other applications where it is desired to obtain braking action by reverse rotation of the driving element may now enjoy the advantages of hydraulic action through the use of a design covered by patent 2,303,041, recently assigned to General Motors Corp.

Basic elements of the unit, as shown in the illustration, include the usual fixed axle, rotating wheel hub, and driving sprocket. Forming an extension of the sprocket is the driving sleeve which is provided with steep pitched threads engaging corresponding threads in the connector. Friction of a lag spring which fits into an annular groove in the connector and has out-turned ends engaging two of the longitudinal keyways in the hub tends to rotate the connector in the same direction as the hub. When the driving sprocket is rotated forward the action of the threads moves the connector to the right and the outer conical surface comes into driving engagement with a corresponding surface on the inside of the hub. When coasting, thread action moves the connector to the left, out of engagement with the hub.



Fluid-filled bellows transmit braking force from sprocket and connector to multiple-disk brake

Sprocket Reversal Effects Braking Action

Backward rotation of the driving sprocket shifts the connector to the left beyond the coasting position into the braking position where it compresses a pair of sylphon bellows filled with brake fluid, transferring the braking force to the applicator plate of the multiple-disk brake. Alternate brake disks rotate with the hub, the others remaining stationary with the brake disk support which is anchored to the frame of the machine. A serrated engagement surface prevents relative slip of connector and bellows applicator plate while brake is being applied.

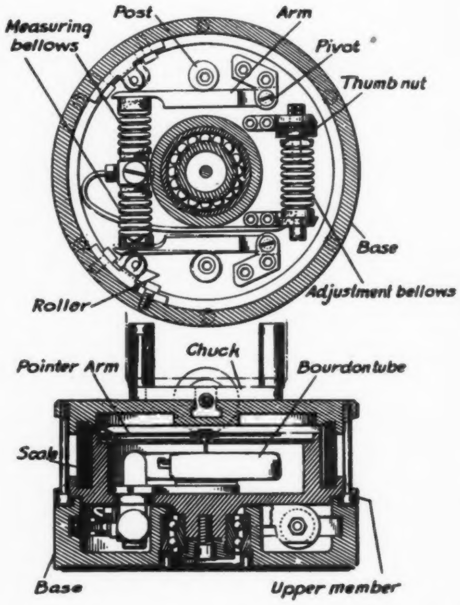
During normal braking, hydraulic action through the bellows furnishes the entire braking force. For emergency braking additional force is transferred through a spacer sleeve which becomes effective after the bellows have been com-

pressed a predetermined amount. It is to be noted that a mechanical advantage is obtained by making the right-hand bellows smaller than the left-hand and fixing the central annular head to which the bellows are attached. In the event of failure of the hydraulic bellows the spacer sleeve serves to transmit the entire braking force.

Hydraulic Bellows Measure Torque

DETERMINATION of the torque required to tighten or loosen screw-type caps on jars, measurement of friction in screw devices, checking of torsional springs, etc., may be readily accomplished through use of a machine covered by patent 2,300,288, assigned to Owens-Illinois Glass Co.

Base of the machine supports, on an antifriction bearing, an upper member carrying a suitable clamping device or chuck for holding one end of the part for which torque measurement is desired. Relative rotation of the two members is opposed by a pair of liquid-filled metal bellows supported between a pair of arms each connected by a pivot to a bracket on the under surface of the upper member. The arms are held in clamping engagement with the bellows by means of posts also



Relative movement of upper member and base builds up pressure in bellows proportional to applied torque

attached to the upper member. Rollers mounted on the base engage the free ends of the arms.

As indicated by broken lines in the plan view, relative rotation of the base and upper member applies pressure to the bellows. One opposing arm is held by the post on the upper member while the other is engaged and compressed by the roller on the base. Pressure built up in the bellows is transmitted to a bourdon gage with a pointer arranged to indicate against a cylindrical scale visible from the outside. Pointer position indicates pressure, the scale being suitably calibrated in torque units. The mechanism being symmetrical, rotation in either direction produces a similar effect.

Adjustment to compensate for temperature changes is provided by a third bellows communicating with the measuring bellows. A thumb nut is used to apply pressure to the adjusting bellows, thus changing the volume of the hydraulic sys-

SPEEDIER WINGS

without sacrifice of strength, fire power or protection. That's what the increased use of cast magnesium parts is giving America's planes. This lightest of structural metals, as cast at the Howard foundries, has ample strength for many weight-saving applications in the planes which are inexorably giving the United States full control of the air. Every pound saved means a little more speed — greater aircraft losses for the enemy, and far fewer for us.

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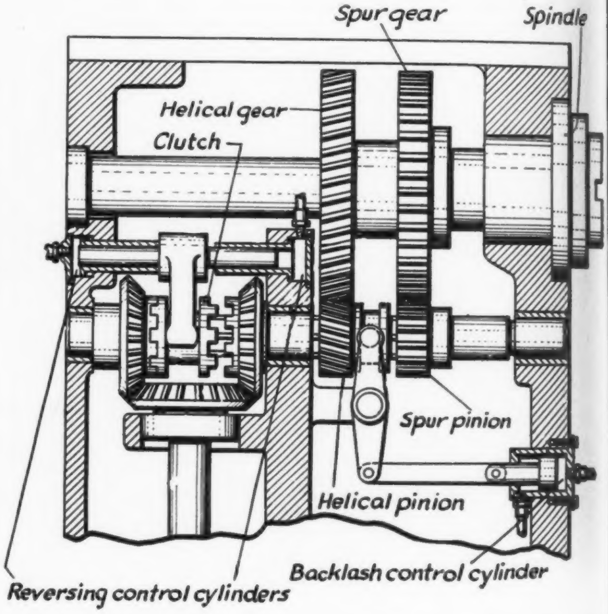
tem and providing an initial pressure which may be used as a zero in calibrating under varying temperature conditions. Backlash in the bellows mechanism is eliminated by proper adjustment of the roller location and of the eccentrically mounted posts.

Eliminates Backlash in Gear Drive

ELIMINATION of backlash in the spindle-driving mechanism of machine tools, especially millers in which cutters may set up vibrations in the gear train, is accomplished through the use of patent 2,302,575, assigned to The Cincinnati Milling Machine Co.

The design, as shown in the illustration, is applied particularly to reversible spindle drives. Means for locking out backlash beween the spur pinion and gear forming the final drive in the train include a pair of helical gears of the same speed ratio as the spur gears. The helical pinion is splined on its shaft and can slide relatively to the helical gear. A



Axial movement of helical pinion with respect to gear absorbs lost motion, eliminates vibration due to tool chatter

shifter fork engaging a spool is used to force the helical pinion in the direction necessary for taking up the lost motion. Force for holding the backs of the helical gear teeth in contact is furnished by hydraulic pressure in a control cylinder. The backlash control is interconnected with the spindle reversing mechanism which also is hydraulically operated.

In the position shown oil pressure acts in the right-hand reversing control cylinder, holding the clutch in engagement with the left-hand bevel gear. This cylinder is hydraulically connected with the left-hand end of the backlash control cylinder so that the helical pinion is urged toward the left. Moving the helical pinion in this direction tends to rotate the helical gear clockwise, looking from the right, the motion being limited by the backlash in the final drive gears.

Reversing is accomplished by admitting oil pressure to the left-hand reversing cylinder and to the right-hand end of the backlash control cylinder, thus moving the clutch into engagement with the right-hand bevel gear and urging the helical pinion to the right. When oil pressure is admitted to both reversing control cylinders, the sleeves move toward each other, holding the clutch in central or neutral position.


Brad Foote
Gears

ASSETS to a BOOKCASE

Applied Kinematics

By J. Harland Billings, professor of mechanical engineering, Drexel Institute of Technology; second edition, published by D. Van Nostrand Co. Inc., New York; 320 pages, 5¾ by 8¾ inches, clothbound; available through Machine Design, *$3.25 postpaid.*

Although described as a second edition, this book has been so completely rewritten that it almost constitutes a new book. In particular, acceleration is much more extensively covered than in the earlier edition, and the effect known as Coriolis' law is discussed in a more practical manner than is the case in most works on the subject. That branch of design known as kinematics or motion analysis has too long been the prerogative of a small group of engineers. With books like this one readily available there is no longer reason to design any mechanism without full and complete analysis of the effects of motion.

While special graphical methods such as, for example, the phorograph are given due prominence, the major emphasis throughout the book is on fundamental principles. It is also interesting to note that calculus, although used sparingly, is not entirely ignored as in some textbooks. Scope of the book includes motion analysis in general, link mechanisms, cam mechanisms, and gearing. Worked examples serve to give practical understanding of the principles set forth.

□ □ □

Torque Converters or Transmissions

By P. M. Heldt, engineering editor, Automotive Industries; published by P. M. Heldt, Nyack, N. Y.; 406 pages, 5¼ by 8¼ inches, clothbound; available through Machine Design, *$4.00 postpaid.*

Covering the whole range of equipment used in transferring power from the engine to the wheels of automotive vehicles, this book will be of interest to all designers concerned with power and speed control. Discussion is not confined solely to torque converters but includes four chapters on friction clutches, automatic clutches, hydraulic couplings and overrunning clutches. Next four chapters cover gear transmissions, following which other methods of torque conversion are discussed, including electric drive, hydrostatic transmissions, hydro-kinetic torque converters, differential or power-shunt transmissions, inertia-types, automatic and power-controlled stepped types, pneumatic transmissions and special designs of geared transmissions.

While design of conventional transmissions is discussed in considerable detail, in the case of the newer and less familiar types the text is largely restricted to explanations of operating principles.

Because automotive equipment must be designed for lightness and compactness yet built to "stand the gaff", the engineering information given should greatly assist designers in other fields who are faced with similar problems of space and weight limitations. Pros and cons of each type of drive are fully discussed and the book is illustrated by numerous cross-sectional drawings, also some charts and photographs.

Emphasis on magnesium at present rests on its use in constructing airplanes. Vast quantities of this lightest of structural metals, extracted by Dow from ocean water and Michigan brine, are devoted to that purpose. But as a weight-saving metal, magnesium faces an even greater era of usefulness. Imagine the countless peace-time applications when production and facilities for fabricating Dowmetal castings and wrought products are available for general purposes! It is a prospect that intrigues every forward looking designer.

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DESIGN ABSTRACTS

Designers, Watch Maintenance Problem!

THINK for a moment of the largest fleet of trucks you have ever known any one operator to have. Was it 15,000 or 25,000 trucks? Whatever the number happens to be, your Uncle Sam is operating a fleet today that makes the largest civilian fleet in the land look puny by comparison. And with this huge and formidable fleet of vehicles comes a huge and formidable problem of maintenance. It is a problem that can make or break us in this war of machines.

No one knows how many lives will be lost because someone did not do his very utmost in the original design. The cab-over-engine is a splendid example of how to make it tough for the mechanic. You gentlemen can probably enumerate many more, like the hard-to-get-at clutch throw-out bearing or the tank you must take apart to get the engine out. But no one can tell how many times that kind of fundamentally unsatisfactory design will stop the movement of a desperately needed load of machine-gun ammunition.

Too often the logical, important checks on design and performance are skipped over. We say there is not time! Too many times the designs flit gaily from drawing board to production without even a respectful bow to the experimental test department.

Far too frequently the advice of practical service men is not sought to learn whether the contemplated design can be readily serviced; in the constant compromise, vehicle maintenance is ignored to achieve a certain style. We are now suffering, and suffering heavily, for these ill-begotten methods.

For all of this war—as long as it lasts, let's have no more of expedient designing!

Parts Numbers Confuse

Another related problem of maintenance that requires the consultation of industry is the question of parts numbers. In motor transport, there are nearly as many different methods of numbering parts as there are different parts lists. One company numbers its parts according to the sequence in which they were designed. Another company assigns numbers on the basis of the grouping of parts. On top of all this, the field organizations have Ordnance nomenclature lists which use the Army system of numbering parts. With these various systems in use, think of the poor mechanic and the parts clerk, at work in Australia or some other far-off post, wading through oceans of inconsistent parts lists.

That brings up the question, which system shall we use? Should we expect the automotive industry to switch over to the Army's system of listing and numbering parts, the standard Nomenclature Lists? Or should the Ordnance Department change its system to conform with the industry's? Or perhaps a system that consolidated the good features of both methods can be developed. This is for all of us to work out. It's not the Army's job, nor is it industry's job. It is our job. *—From talk by Brig.-Gen. James Kirk, Chief of Maintenance Branch, Field Service Division, Ordnance Dept., at the recent S. A. E. Annual Meeting, Detroit.*

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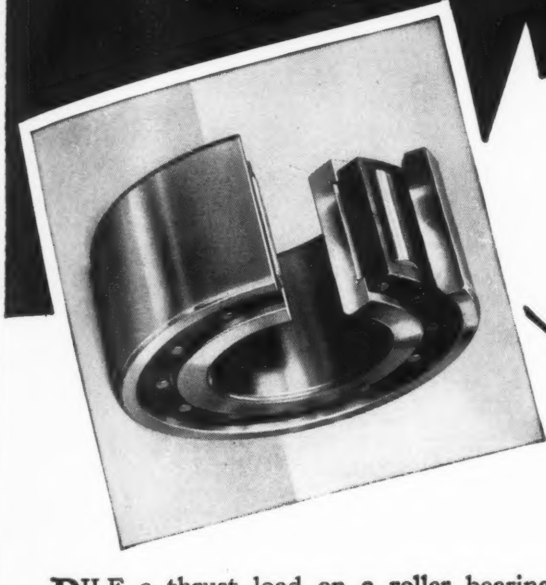

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All ROLLWAY THRUST BEARINGS are Free from Radial Loads

PILE a thrust load on a roller bearing that's already carrying a radial load and you introduce complex stresses that tend to force the rollers from the race . . . that tend to increase sliding friction and wear-back between the roller ends and the radius of the race . . . and that tend to cause earlier fatigue failure.

That's why Rollway Solid-Cylindrical Roller Bearings split every load into its two simplest components of *pure* radial and *pure* thrust . . . carrying each of these on separate roller assemblies at RIGHT ANGLES TO THE ROLLER AXIS. Both torque per bearing and load per roller are substantially reduced. You get greater roller cross-section and greater roller contact area per unit of load, hence more strength to meet stress, and less hazard of spalling and brinelling the race.

You can usually change over from other bearings to Rollways of higher load capacities without increasing boundary dimensions. But, for maximum life and service, your bearings should be carefully chosen as to size and type. Send us your drawings, or a description of your application, for free and confidential bearing recommendation.

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Strain-Rosette Analysis

(*Continued from Page* 104)

of the principal strains, can be obtained from Equations 1. In applying these equations to the principal stress directions it must be noted that $\epsilon_x = \epsilon_1$, $\epsilon_y = \epsilon_2$ and $\gamma_{xy} = 0$.

$$\left.\begin{aligned}\epsilon_a &= \epsilon_1 \cos^2\theta_a + \epsilon_2 \sin^2\theta_a \\ \epsilon_b &= \epsilon_1 \cos^2\theta_b + \epsilon_2 \sin^2\theta_b \\ \epsilon_c &= \epsilon_1 \cos^2\theta_c + \epsilon_2 \sin^2\theta_c \\ \epsilon_d &= \epsilon_1 \cos^2\theta_d + \epsilon_2 \sin^2\theta_d\end{aligned}\right\} \qquad (7)$$

In applying this procedure, Osgood[5] used strain gages on lines acting at 45 degrees as shown in *Fig.* 6. Then in Equations 7, the angles are $\theta_b = \theta_a + \pi/4$, $\theta_c = \theta_a + \pi/2$, $\theta_d = \theta_a + 3\pi/4$. Placing these values of the angles in Equations 7 the values of the strains become

$$\left.\begin{aligned}\epsilon_a &= \frac{1}{2}(\epsilon_1+\epsilon_2) + \frac{1}{2}(\epsilon_1-\epsilon_2)\cos 2\theta_a \\ \epsilon_b &= \frac{1}{2}(\epsilon_1+\epsilon_2) - \frac{1}{2}(\epsilon_1-\epsilon_2)\sin 2\theta_a \\ \epsilon_c &= \frac{1}{2}(\epsilon_1+\epsilon_2) - \frac{1}{2}(\epsilon_1-\epsilon_2)\cos 2\theta_a \\ \epsilon_d &= \frac{1}{2}(\epsilon_1+\epsilon_2) + \frac{1}{2}(\epsilon_1-\epsilon_2)\sin 2\theta_a\end{aligned}\right\} \qquad (7a)$$

These four equations determine three unknowns ϵ_1, ϵ_2 and θ_a. The best solution for these, by the method of least squares, can be shown to be

$$\left.\begin{aligned}\epsilon_1 &= \frac{1}{2}\left[\frac{1}{2}(\epsilon_a+\epsilon_b+\epsilon_c+\epsilon_d) + \sqrt{(\epsilon_a-\epsilon_c)^2+(\epsilon_b-\epsilon_d)^2}\right] \\ \epsilon_2 &= \frac{1}{2}\left[\frac{1}{2}(\epsilon_a+\epsilon_b+\epsilon_c+\epsilon_d) - \sqrt{(\epsilon_a-\epsilon_c)^2+(\epsilon_b-\epsilon_d)^2}\right]\end{aligned}\right\} \qquad (8)$$

$$\tan 2\theta_a = -\frac{\epsilon_b-\epsilon_d}{\epsilon_a-\epsilon_c}$$

Placing the above values of the principal strains in expressions for the principal stresses are given by Equations 4, the values of the principal stresses are

$$\left.\begin{aligned}S_1 &= \frac{E}{2(1+m)}\left[\frac{1}{2}\left(\frac{1+m}{1-m}\right)(\epsilon_a+\epsilon_b+\epsilon_c+\epsilon_d) + \sqrt{(\epsilon_a-\epsilon_c)^2+(\epsilon_b-\epsilon_d)^2}\right] \\ S_2 &= \frac{E}{2(1+m)}\left[\frac{1}{2}\left(\frac{1+m}{1-m}\right)(\epsilon_a+\epsilon_b+\epsilon_c+\epsilon_d) - \sqrt{(\epsilon_a-\epsilon_c)^2+(\epsilon_b-\epsilon_d)^2}\right]\end{aligned}\right\} \qquad (9)$$

For many purposes, in using the above equations for ductile materials, a value of $m = 1/3$ can be assumed. With this value of Poisson's ratio, Equations 9 reduce to

$$\left.\begin{aligned}S_1 &= \frac{3E}{8}\left[(\epsilon_a+\epsilon_b+\epsilon_c+\epsilon_d) + \sqrt{(\epsilon_a-\epsilon_c)^2+(\epsilon_b-\epsilon_d)^2}\right] \\ S_2 &= \frac{3E}{8}\left[(\epsilon_a+\epsilon_b+\epsilon_c+\epsilon_d) - \sqrt{(\epsilon_a-\epsilon_c)^2+(\epsilon_b-\epsilon_d)^2}\right]\end{aligned}\right\} \qquad (9a)$$

The above equations give expressions for the principal

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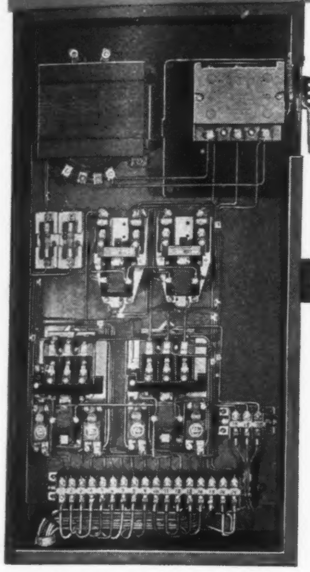
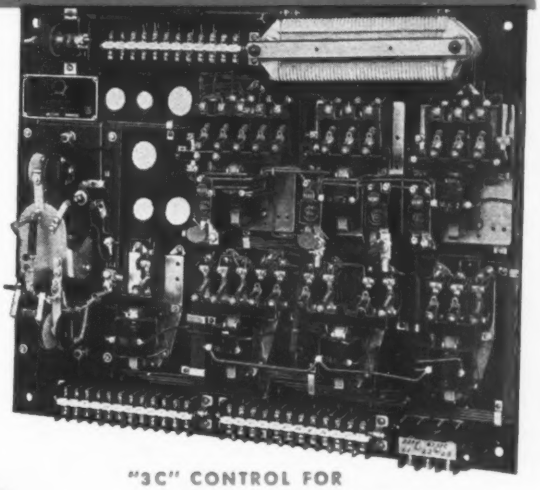
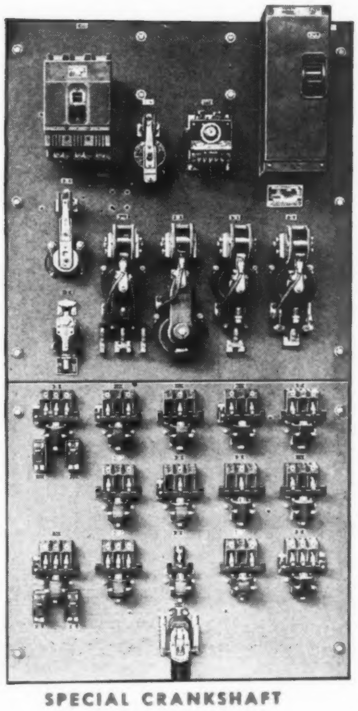


SPECIAL "3C" MACHINE TOOL CONTROL PANEL



"3C" CONTROL FOR HORIZONTAL BORING MILL



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stresses directly in terms of the measured strains at the point.

Equiangular Strain Rosette: Another procedure suggested by Mindlin[6] consists of measuring the strains in the three directions a, b and c, as shown in *Fig.* 7, such that $\theta_a = 0$, $\theta_b = 120°$ and $\theta_c = 240°$. This strain-rosette is called an equiangular strain rosette. To determine the expressions for the principal stresses in this case, considering Equations 1, substituting values of $\theta_a = 0$, $\theta_b = 120°$, $\theta_c = 240°$ and solving the three equations for the strains ϵ_x, ϵ_y and γ_{xy} their values are:

$$\left.\begin{aligned} \epsilon_x &= \epsilon_a \\ \epsilon_y &= \frac{1}{3}(2\epsilon_b + 2\epsilon_c - \epsilon_a) \\ \gamma_{xy} &= \frac{2}{3}\sqrt{3}(\epsilon_c - \epsilon_b) \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots (m)$$

Principal strains can be obtained by placing the values of the strain components from Equations a in Equations 3. The principal strains are then determined by

$$\left.\begin{aligned} \epsilon_1 &= \frac{1}{3}(\epsilon_a + \epsilon_b + \epsilon_c) + \\ &\quad \frac{\sqrt{2}}{3}\sqrt{(\epsilon_a - \epsilon_b)^2 + (\epsilon_b - \epsilon_c)^2 + (\epsilon_c - \epsilon_a)^2} = A + B \\ \epsilon_2 &= \frac{1}{3}(\epsilon_a + \epsilon_b + \epsilon_c) - \\ &\quad \frac{\sqrt{2}}{3}\sqrt{(\epsilon_a - \epsilon_b)^2 + (\epsilon_b - \epsilon_c)^2 + (\epsilon_c - \epsilon_a)^2} = A - B \end{aligned}\right\} \quad (10)$$

Formulas for the principal stresses are obtained by placing the values of the principal strains from Equations 10 in Equations 4. Doing this the values of the principal stresses are

$$\left.\begin{aligned} S_1 &= E\left(\frac{A}{1-m} + \frac{B}{1+m}\right) \\ S_2 &= E\left(\frac{A}{1-m} - \frac{B}{1+m}\right) \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots (11)$$

where

$$A = \frac{1}{3}(\epsilon_a + \epsilon_b + \epsilon_c) \quad \text{and}$$

$$B = \frac{\sqrt{2}}{3}\sqrt{(\epsilon_a - \epsilon_b)^2 + (\epsilon_b - \epsilon_c)^2 + (\epsilon_c - \epsilon_a)^2} \quad \ldots\ldots\ldots\ldots (12)$$

Graphical Solution by Land's Circle[7]: It is sometimes convenient to determine the values of the principal stresses by means of a graphical procedure referred to as the Land's or Dyadic circle method. The procedure involved will be explained for the case in which the three strains are positive. These strains are represented in *Fig.* 8a by ϵ_a, ϵ_b and ϵ_c and their directions by θ_a, θ_b and θ_c. From any point T (*Fig.* 8b), the values of these three strains are as shown at angles of $2\theta_a$, $2\theta_b$ and $2\theta_c$ with respect to the negative direction of the x axis. A negative strain would

[6] R. D. Mindlin—"The Equiangular Strain-Rosette", *Civil Engineering*, Page 895, August, 1938.

[7] For a discussion of this method the reader is referred to "The Determination of Stresses From Strains on Three Intersecting Gage Lines and Its Application to Actual Tests"—W. R. Osgood and R. G. Sturm, Research Paper No. 559, U. S. Bureau of Standards, *Journal of Research*, Vol. 10, May, 1933, Page 685.


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be laid off in the opposite direction from T to that shown. At the ends of the strain lines three perpendiculars P_1, P_2, P_3, respectively are drawn. In each case, the side away from T is shaded if the corresponding strain is positive. A circle is drawn which is tangent to the three perpendiculars either on all the shaded sides or all the unshaded sides. In general there will be four possible circles but only one will satisfy the condition imposed. Through the center of the circle are drawn the axis Ox and tangent to the circle the axis Oy parallel respectively to the x and y axes of *Fig.* 8*a*. There are two possible points O in the figure. The one selected is such that the positive direction of x intersects the circle as shown when the tangent is on the unshaded side. TR is perpendicular to Ox. Then

$$\epsilon_x=\overline{OR};\ \epsilon_y=\overline{RX}\ \text{ and }\ \gamma_{xy}=2\overline{RT} \qquad (13)$$

The above statements can be proved as follows:

Considering the diameter X_1Y_1 passing through the center M and parallel to the direction of the ϵ_a strain, the projection of Y_1MRT on the diameter X_1Y_1 can be shown to be ϵ_a. That is,

$$\epsilon_a=\overline{MY_1}+\overline{MN}+\overline{NR_1} \qquad (n)$$

or

$$\epsilon_a=\left(\frac{\overline{OR}+\overline{RX}}{2}\right)+\left(\frac{\overline{OR}-\overline{RX}}{2}\right)\cos 2\theta_a+\overline{TR}\sin 2\theta_a \qquad (o)$$

This is the expression for the strain ϵ_a as given by Equation 1 provided values for OR, RX and RT are as given in Equation 13. Thus the values of the strain components referred to the axes x and y as defined in Equations 13 are determined graphically in *Fig.* 8.

Values of the principal strains and the maximum shearing strain may be determined by considering the graphical construction in *Fig.* 9. Remembering that the intercepts OR and RX (*Fig.* 8) are the strains, it is seen that the maximum and minimum strains are obtained when the diameter selected is intercepted by the point T itself as shown in *Fig.* 9*a*. Then it can be shown that the principal strains and their directions are determined in *Fig.* 9*a* by

$$\epsilon_1=\overline{VT},\ \epsilon_2=\overline{VT},\ \phi=\angle UOX \qquad (14)$$

To determine the maximum shearing strains it is again convenient to refer to *Fig.* 8. In this figure the shearing strain was shown to be TR = twice the perpendicular distance from T drawn to a diameter. It is seen, therefore, that the greatest shear strain is obtained when the diameter is perpendicular to the line connecting point T and the center of the circle. That is, the maximum shearing strain is given by

$$(\gamma_{xy})_{max}=\gamma=2\overline{MT} \qquad (15)$$

This value of the shear strain is shown in *Fig.* 9*b*. The axes x_s and y_s which can be shown to define the direction of this shear strain are also represented.

Knowing the values of the principal strains as stated by Equations 14, the values of the principal stresses are easily calculated from Equations 4.

The strain-rosette method has been used considerably

for determining the stresses in many machine and structural members. For example, the Aluminum Research Laboratories have used the method in laboratory studies of locomotive side rods, bearing plates, beams, batten and gusset plates.

Determination of stresses in webs of I-beams may be complicated by local stresses produced by concentrated loads. These local stresses must be obtained in the case of long-span, thin-webbed beams or for heavier beams with short spans. Direct information concerning these stresses is afforded by the strain-rosette method.

A study[8] was also made using the strain-rosette method to determine the stress condition in full-size welded branch connections for high-pressure piping. This is another type of problem in which the determination of the stresses by theoretical methods is impractical.

Recently the method has been used for studying stresses in parts of aircraft. There are many other applications in which this procedure could be effectively used by the designer and stress analyst.

[8]F. L. Everett and A. McCutchan—"Investigation of Stress Conditions in a Full-Size Welded Branch Connection", *Transactions* A.S.M.E., 1938, Page 399.

Acceleration Analysis

(*Continued from Page* 92)

$A^t_{C_2C_3}$ is unknown in magnitude but directed parallel to the face of the follower

Since $\omega_3 = V_{C3}/O_3C_3$, counterclockwise, the component $2V_{C_2C_3}\omega_3 = 2V_{C_2C_3}(V_{C3}/O_3C_3)$ directed upward normal to the follower face.

The acceleration diagram, *Fig.* 8*c*, is now started by drawing from the pole point O_a a vector O_ac_2 representing A_{C_2}. From this is subtracted the vector $2V_{C_2C_3}\omega_3$ in accordance with the acceleration vector equation. From the tail of this last vector a line is drawn in the direction of the component $A^t_{C_2C_3}$.

The solution is completed by writing $A_{C_3} = A^n_{C_3} +\!\!\rightarrow A^t_{C_3}$ in which $A^n_{C_3} = [O_3C]\omega_3^2 = (V_{C_3})^2/[O_3C]$ directed from C toward O_3. $A^t_{C_3}$ is unknown in magnitude but directed normal to O_3C. Vector $A^n_{C_3}$ is drawn from pole point O_a and through its tip a line is drawn in the direction of $A^t_{C_3}$. The intersection of this line and the line previously drawn parallel to the follower face locates the tip of the A_{C_3} vector. Any numerical values desired can now be obtained from the acceleration diagram. For example, the angular acceleration of the follower can be determined by scaling the numerical value of $A^t_{C_3}$ and dividing by the length O_3C.

EXAMPLE 4: *Fig.* 9 shows the analysis of a slightly more complicated linkage than has been treated in the previous examples. The velocity diagram is shown at b and the acceleration diagram at c. The steps in the acceleration solution are outlined below.

$$A_{A_2} = A^n_{A_2} = [O_2A]\omega_2^2, \text{ computed}$$

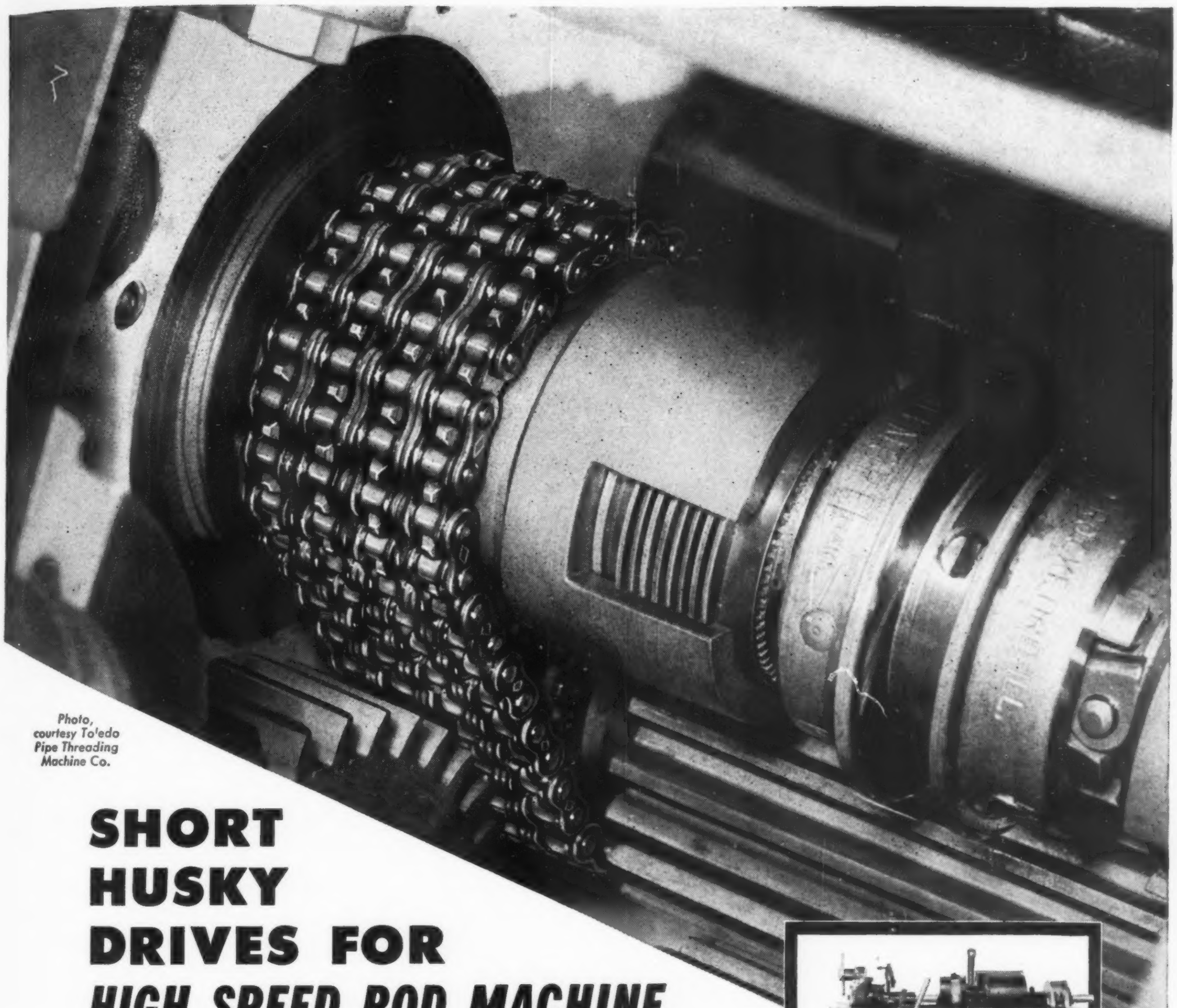
$$A_{A_3} = A_{A_2} \rightarrow A_{A_2A_3}$$

$$= A_{A_2} \rightarrow A^n_{A_2A_3} \rightarrow A^t_{A_2A_3} \rightarrow 2V_{A_2A_3}\omega_3 \quad (1)$$

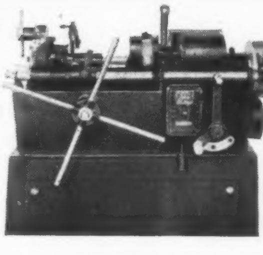
$$A_{A_3} = A^n_{A_3} +\!\!\rightarrow A^t_{A_3} \quad (2)$$

$$A^n_{A_2A_3} = 0$$

Values of $2V_{A_2A_3}\omega_3$ and $A^n_{A_3}$ are computed, then Equa-



Photo, courtesy Toledo Pipe Threading Machine Co.



Large illustration shows short center 4-strand No. 82 Diamond Roller Chain Drive on the compact "Toledo" high speed rock drill rod machine, a good example of an extremely short center drive. Note the large number of sprocket teeth that share the load.

tions 1 and 2 solved simultaneously to determine the acceleration of point A on link 3. The acceleration of B is found by the direct proportion, $A_B/[O_3B] = A_{A3}/[O_3A]$. The solution is completed by writing and solving, $A_C = A_B \mathrel{+\!\!\rightarrow} A^n_{CB} \mathrel{+\!\!\rightarrow} A^t_{CB}$ in which A^n_{CB} can be computed and A_C and A^t_{CB} are known in direction.

A mistake frequently made in an otherwise correct acceleration analysis is the omission of the component $2V\omega$. In an article, "Adapting Phorograph Method of Accelerations," Machine Design, November, 1934, an illustration of a crank-shaper of the same proportions as shown here in *Fig.* 9*a* was used. The solution presented did not take the Coriolis component into account; as a result the value for acceleration of the ram was in error by approximately 40 per cent of the correct value. *Fig.* 10 shows clearly the effect of omitting the Coriolis component. The angular acceleration of the oscillating arm (link 3) of the crank-shaper in *Fig.* 9 has been plotted against crank position for one-half the return stroke. The full line shows the correct value and the broken line the value obtained if the component $2V_{A_2A_3}\omega_3$ is omitted. The two curves have points in common at the beginning of the stroke (where $\omega_3 = 0$) and at the midpoint (where $V_{A_2A_3} = 0$). Elsewhere they diverge widely, the difference becoming as great as 60 per cent for some crank positions.

Business and Sales Briefs

ANNOUNCED by The Bunting Brass & Bronze Co., Toledo, Ohio, is the appointment of George H. Adams as executive vice president. He will supervise all manufacturing, sales and research operations, being well prepared for this by a wide experience in engineering, manufacturing and application of all types of bearings.

♦

James R. Hewitt has been elected vice president of American Manganese Steel division, American Brake Shoe & Foundry Co., Chicago.

♦

All assets and business of the former Lindsay Structure division of Dry-Zero Corp. have been taken over by a new organization to be known as Lindsay and Lindsay, Chicago. Harvey B. Lindsay, formerly president of the Dry-Zero company, has resigned to direct the activities of the new organization. Offices are located at 22 West Adams street, Chicago, and 60 East Forty-second street, New York city.

♦

For the past nine years associated as research chemist with Harvel Research Corp., S. Caplan has become the research manager and acting technical director of the Irvington Varnish and Insulator Co. Mr. Caplan succeeds C. F. Hanson who has been appointed chief consulting engineer and will be responsible for expediting work on war production.

♦

William J. Thomas, manager of mechanical tube sales, Babcock & Wilcox Tube Co., Beaver Falls, Pa., has been appointed assistant general sales manager of the company. Another appointment is that of Leon E. Jeanneret, formerly assistant general sales manager, as manager of sales, welded tube division, with offices and plant at Alliance, O. Edward A. Livingstone, general sales manager at Beaver Falls, will

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FIND METAL-CUTTING HORSEPOWER Quickly!

It's Easy with the G-E MOTORULE*

This newly developed load calculator makes it easy to figure the motor horsepower required for metal-cutting operations when the recommendations of the machine builder are unavailable. Its advantages? You can avoid *undermotoring* and save yourself production delays; you can avoid *overmotoring* and save the nation vitally needed steel, copper, and aluminum.

The G-E MOTORULE is accurate for a wide variety of cutting operations on lathes, drills, milling machines, and planers. It works on a wide range of materials, because you start from a convenient table of constants for the material being cut.

The results of many years of work by metal-cutting authorities were used by G-E engineers as a basis for the MOTORULE. The formulas were checked against actual load tests, and leading machine-tool builders were consulted.

The MOTORULE will help you in making sure of adequate motor capacity on machines being put to new war work, and in selecting motors for machines formerly driven from line shafting. To get your MOTORULE, just get in touch with your G-E Motor Representative. Or, if you wish, mail the coupon direct to General Electric, Schenectady, N. Y.

First you refer to a convenient table of constants, printed on each rule, choosing the constant for the particular type of metal to be cut. Then by setting the scales to the known cutting speed, feed, and cut, you arrive at the cutting power required on the basis of ideal tool and machine conditions. Complete instructions are furnished with each MOTORULE.

*The MOTORULE is not intended to supplant the instructions of machine builders as to the power requirements of their machines. It is offered to fill the gap when these recommendations are unavailable.

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Standard G-E Motors Are Generally Available without Delay for War Jobs

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GENERAL ELECTRIC

also be general sales manager of the welded tube division at Alliance.

♦

In charge of the Chicago office for the past 20 years, L. C. Rathsburg has been elected vice president of Lakeside Malleable Castings Co., Racine, Wis. He will continue to be located at 122 South Michigan avenue, Chicago.

♦

Associated with the company in various capacities for 17 years, Charles H. Eisenhardt has been made assistant manager, electrical wire rope and construction materials sales division, American Steel & Wire Co., Cleveland.

♦

Formerly industrial sales manager, Milwaukee Paint division, Pittsburgh Plate Glass Co., Louis F. Theurer has been made West Coast divisional director, succeeding Floyd S. Green. R. I. Ogle, industrial paint sales representative in the Chicago territory, will be industrial sales manager at Milwaukee.

♦

Election of Warren F. Fryburg as director and vice president of The Black & Decker Electric Co., Kent, Ohio, has been announced. Mr. Fryburg was previously sales manager of the company. His background consists of seventeen years' technical and marketing experience in the field of fractional-horsepower electric motors.

♦

I. H. Anderson has been made district manager of sales, Steel and Tubes division, Republic Steel Corp., in New York, succeeding L. M. Hogan, resigned. He has been associated with the New York office for the past six years. D. A. Shardelow, who has been associated with the company since 1936 in its Dayton, O. office, has been transferred to Indianapolis as district sales manager.

♦

Naming of Robert S. Sloan as welding specialist for the Westinghouse Electric & Mfg. Co. in the North Pacific area has recently been announced. Mr. Sloan will assist in the application of the company's welding equipment throughout the territory comprising Washington, Oregon, Northern Idaho and Montana.

♦

For the last thirty-two years connected with The Osborn Mfg. Co., Cleveland, Henry T. Riddick has been named sales service manager of the company's brush division.

♦

George Conlee has been appointed to the post of engineering-sales representative for the Fleetwings Hydraulic division, Fleetwings Inc., Birstol, Pa.

♦

On January 1, 1943, Hercules Powder Co. Inc., Wilmington, Del. will mark its thirtieth anniversary. The company has grown to 60 plants and offices, serving 55 or more industries, since its inception.

♦

Associated for some time with Crucible Steel Co. of America, John A. Ross has been appointed manager of the company's alloys sales department, located in New York.

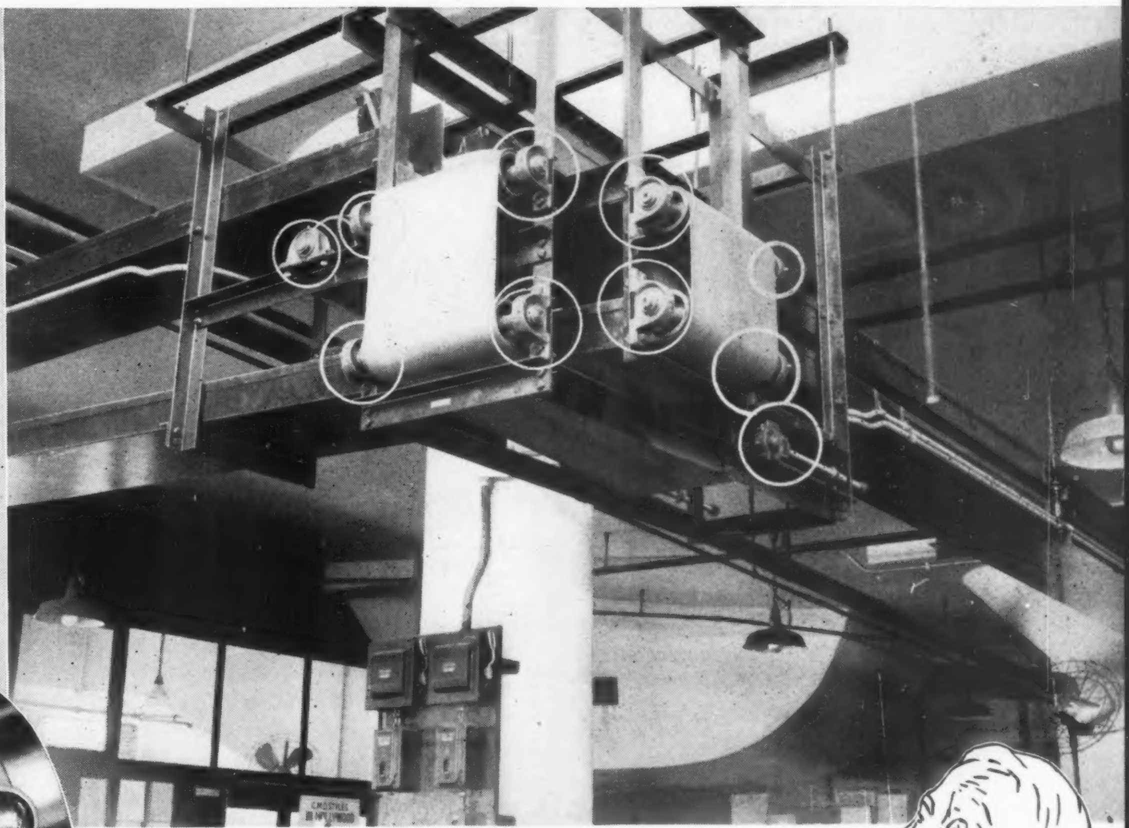
♦

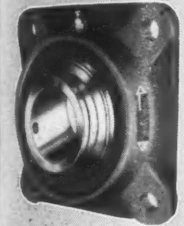
N. M. Forsyth, general sales manager, Pump Engineering Service Co., division of Borg-Warner Corp., Cleveland, has been made vice president in charge of sales.

♦

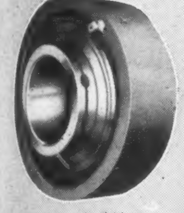
Connected with the rubber industry for twenty-eight years, L. R. Howes has been named sales engineer for the automotive and aeronautic departments of the national sales and

CUT THE "OVERHEAD" OF MAINTENANCE

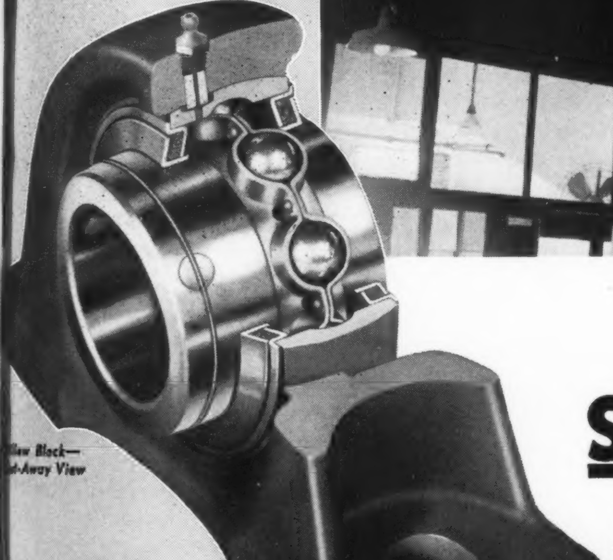




Flange Unit

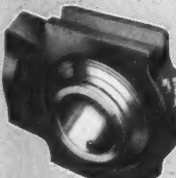


Cartridge Unit

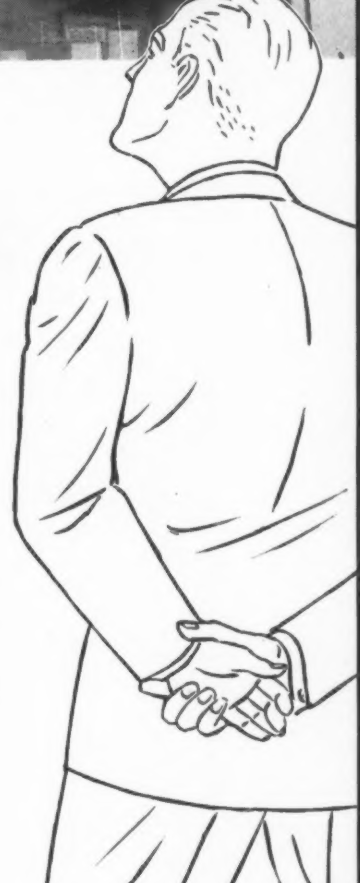


Pillow Block—Cut-Away View

Extended Inner-Race Bearing



Take-Up Unit



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SEALMASTER

Ball Bearing Units

Maintenance is always an overhead expense—usually involves a shutdown of the machine, a loss of machine hours, a substitution of unproductive man-hour charges.

Where SealMaster Bearings are used, however, the sealed-in lubrication permits long, uninterrupted operating periods. Patented felt flingers form a free-running seal, self-aligning and non-distorting.

With the great importance of materials handling, under today's conditions, the installation above illustrates how SealMasters took the "overhead" out of an overhead conveyor.

For standard and special production machinery, SealMaster Bearings are made in all necessary types and sizes for ideal performance. Write for Bulletin No. 840 of types, sizes and data.

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service division of B. F. Goodrich Co., with headquarters at 5400 East Olympic boulevard, Los Angeles.

♦

Formerly assistant general sales manager at Lockheed Aircraft Corp., Thomas H. Corpe has been named general sales manager of Elastic Stop Nut Corp., Union, N. J. He has also been associated with General Motors Corp. as a technical engineer in charge of its proving ground, and in various sales positions.

♦

Reliance Electric & Engineering Co., Cleveland, has leased the plant recently occupied by the Stoker division of the Pocahontas Fuel Co. Funds for the new facilities and equipment will be supplied by the Navy department. The acquisition of these additional motor manufacturing facilities, to be operated separately as the Marine division, gives the company three plants in Cleveland and will permit substantial increase in its production for the Navy.

♦

Effective immediately is the appointment of W. E. Griffiths as assistant manager of sales, flat rolled products of Allegheny Ludlum Steel Corp. He was formerly manager of the product development department.

♦

Manager of the engineering service office in Detroit for Adel Precision Products Corp., Burbank, Calif., Harold P. Wade has been appointed general manager.

♦

The board of directors of the Aircraft Parts Development Corp., Summit, N. J., has announced the appointment of Dan C. Hungerford as president and general manager. Mr. Hungerford was formerly vice president and a director of the Elastic Stop Nut Corp.

♦

Offices of Eicor Inc., manufacturers of dynamotors, direct-current motors, converters, power plants and other rotary electrical apparatus, are being moved to the DFC building at 1501 West Congress street, Chicago. Considerable more space and production facilties will be provided to meet the increased need for the company's equipment in the war program.

♦

Officers elected for 1943 at the first wartime meeting of the Meehanite Research Institute of America Inc., were: Oliver Smalley, Meehanite Metal Corp., Pittsburgh, is president; H. B. Hanley, American Laundry Machinery, Rochester, N. Y., is vice president; and A. M. Galbraith, Meehanite Metal Corp., Pittsburgh, is secretary-treasurer.

♦

J. Wesley Cable, research and development engineer of Induction Heating Corp., New York, has assumed the added responsibilities of general sales manager of the corporation

♦

Formerly located in Clinton, Mass., Tupper Plastics has now become fully established in its new factory at Farnumsville, Mass.

♦

Succeeding the late H. E. Richardson, Charles W. Test has been appointed district sales manager at Philadelphia for Youngstown Sheet & Tube Co., with offices at 1400 South Penn Square.

♦

With the B. F. Goodrich Co., Akron, O., since 1923 M. G. Huntington now becomes manager of the Washington office of the company. In his new capacity he succeeds K. D. Smith who has assumed new duties with headquarters in Detroit.